Journal of the Kansas Entomological Society

(Central States Entomological Society)

Vol. 29 July, 1956 Number 3

PUBLICATION COMMITTEE

MARY H. MICHENER, Editor, Lawrence
WALLACE E. LaBERGE, Acting Editor
R. E. BEER, Lawrence R. H. PAINTER, Manhattan
DWIGHT ISELY, Fayetteville, Ark.

PAUL BOWEN LAWSON
1888-1954

Entered as second-class matter June 7, 1939 at the Post Office at Manhattan, Kansas, under the Act of August 24, 1912.

JOURNAL OF THE KANSAS ENTOMOLOGICAL SOCIETY

A quarterly journal published in January, April, July, and October devoted to Entomology in the Western Mississippi Basin and the proceedings of the Kansas Entomological Society.

Manuscripts for publication may be sent to the Editor, Mary H. Michener, care of the Department of Entomology, University of Kansas, Lawrence, Kansas or to any member of the publication committee.

The Kansas Entomological Society does not make exchanges since the Society does not maintain a library.

Subscriptions to the Journal must be paid in advance. The subscription rate is so low that second notices are not ordinarily sent out.

Payment of Canadian or other foreign subscriptions and bills must be made by international Postal Money Order or by a draft on a New York bank and payable in U.S.A. dollars.

Subscribers are urged to give us their full cooperation in these matters.

Subscriptions should be sent to Fred A. Lawson, Department of Entomology, Kansas State College, Manhattan, Kansas.

Subscriptions in the U.S.A.	**$2.00 per year**	**Single Copy**
Canadian or foreign subscriptions,	**$2.25 per year**	**75 cents**

KANSAS ENTOMOLOGICAL SOCIETY

President, CHARLES G. LINCOLN
Vice-President, WILBUR R. ENNS
Secretary-Treasurer, FRED A. LAWSON

Vol. 28, No. 3, July, 1956

This issue mailed July 31, 1956

Kansas Entomological Society
Vol. 29 July, 1956 Number 3

THE WALKER TYPES OF BIBIONIDAE (DIPTERA)

Dept. of Zoology and Entomology
University of Hawaii
D. Elmo Hardy

The Bibionidae described by Francis Walker have been poorly defined in the literature, and much confusion has existed regarding most of his species. While studying at the British Museum (Natural History) during the summer of 1954, I had an opportunity to examine most of his types. Of the twenty-one species investigated only five have been previously recognized in the literature as valid species. In nearly all cases new synonyms or changes of combination are involved. Two of the types have apparently been lost.

Penthetria ignicollis (Walker)

Plecia ignicollis Walker, 1848, List Dipt. Ins. Brit. Mus. 1:116.

A synonym of *P. japonica* Wiedemann, refer to discussion under that species.

Penthetria japonica Wiedemann

Penthetria japonica Wiedemann, 1830, Aussereurop. Zweifl. Ins. II:618.
Plecia ignicollis Walker, 1848, List Dipt. Ins. Brit. Mus. 1:116. New synonymy.

I apparently overlooked the type of *Plecia ignicollis* Walker in the British Museum but Paul Freeman has reported that the type series consists of a male and a female from Canton, China; a holotype has not been designated. He has examined these for me and has reported that they compare very favorably with the specimens they have of *P. japonica,* from China and India, but do not fit the specimens of *melanaspis* Wied., from Java. *P. japonica* is the common species in the Orient—I have studied specimens from Japan, China, and India—while contrary to many previous reports *P. melanaspis* seems to be restricted to Indonesia. Both *japonica* and *ignicollis* have commonly been considered synonyms of *menalaspis* but as pointed out by Duda (1930:12) *japonica* is a distinct species.

Plecia bimaculata Walker

Plecia bimaculata Walker, 1856, Insecta Saunder. 1:422.

A synonym of *Philia spinipes* Say, see discussion under that species.

Plecia costalis Walker

Plecia costalis Walker, 1856, Trans. Ent. Soc. Lond. 5:422.
Plecia imperialis Schiner, 1867, Dipt., Reise der Osterreichischen Fregatte Novara um die Erde, p. 22. New synonymy.

Three specimens are in the British Museum under the name *Plecia costalis* Walker. One male and one female are labeled "Type, Mexico, 1904, 85. *Plecia nigerrima* Bell." Also one female labeled *"costalis,"* the locality I cannot be sure of, it seems to be "Paramo" or possibly "Parino," this name is followed by "Tolima, 68.4." I believe the latter may possibly be the type, the data on the first two specimens is not that of Walker's. I

would question the Mexico label on these, they probably are from Colombia; the type locality was Colombia.

Plecia costalis Walk. *(nec* Wiedemann) was considered by Edwards to be a synonym of *Penthetria nigerrima* (Bellardi) and the first two specimens mentioned above were probably labeled by Edwards. I accepted this synonymy in my revision of the New World *Penthetria* (Hardy, 1945: 388). The specimens in the collection are *Plecia* and are obviously the same as *P. imperialis* Schiner. They compare with other specimens of *imperialis* in the collection and also with my description and figures of this species (Hardy, 1945:411, figs. 145a-b).

Plecia dorsalis Walker

Plecia dorsalis Walker, 1857, Proc. Linn. Soc. Lond. 1:5. Preoccupied by
Plecia dorsalis Macquart, 1838, Dipt Exot. 1:86. Described from Singapore.

I did not find the type in the British Museum and have had Paul Freeman make a search for it. He was unable to find it and the type apparently has been lost. This has been considered a synonym of *P. fulvicollis* (Fabricius) by most authors. It is impossible to place the species without the type, the original description fits all of the species which have the thorax entirely rufous.

Plecia subvarians Walker

Plecia subvarians Walker, 1857, Proc. Linn. Soc. Lond. 1:105.

The type male from Sarawak, Borneo, is in the British Museum collection. The species was unrecognizable from the brief original description but has been redescribed and figured by Edwards (1919, Journ. Fed. Mal. States 8(3):8) also by myself in a revision of the Pacific *Plecia* (in press). I had previously studied specimens compared with the type by Edwards and have identified specimens from Java, Sumatra, and Ceram. Edwards also recorded it from Java, Sumatra, and Singapore.

This belongs in the *fulvicollis* complex by having the thorax entirely opaque orange to rufous. It is related to *P. ruficornis* Edwards and fits his description except for its larger size and very different genitalia. It is best distinguished by the presence of two pairs of moderately strong lobes on the hind margin of the ninth sternum. The lateral lobes are rather elongate and slender and extend well beyond the apices of the claspers. The median lobes are short and broad and are separated by a "U" shaped concavity in the middle of the hind margin. Also the lateral lobes of the ninth tergum are broad and rounded at apices, not so acutely pointed as in *ruficornis*. The claspers are short, broad, and rounded at apices.

Plecia rufithorax Walker

Plecia rufithorax Walker, 1848, List Dipt. Ins. Brit. Mus. 1:116.

The type female and eight specimens from the type series are in the British Museum. This species has been properly placed in the literature and has been adequately described and figured in my revision of the New World *Plecia* (Hardy, 1945:434-435, figs. 171a-d).

Philia fulvicoxa (Walker)

Dilophus fulvicoxa Walker, 1848, List of Dipt. Ins. Brit. Mus. 1:117.

This species is known only from the type female from St. Martin Falls, Albany River, Hudson Bay, no other records are known. Walker's brief description seems adequate since the species is very distinctive because of its all dark brown to black legs, except for the rufous front coxae.

Philia fulvimacula (Walker) new comb.

Plecia fulvimacula Walker, 1848, List Dipt. Ins. Brit. Mus. 1:116.

This species has never been recognized since the original description. The type female, from Venezuela, is a *Philia,* not a *Plecia* as indicated by Walker. There are three sets of spines on the front tibia, two near the basal one-fourth of the segment and five located in a row at the middle. The apical spur of the front tibia is two times larger than the apical spines. Head all black, subshining, rostrum not produced beyond bases of the antennae. The sclerotized portion of the head before the eyes, and also that portion behind eyes, is about two-thirds to three-fifths as long as the eye. The ocelli are situated on a strong prominence. Antennae twelve segmented, not counting the button-like tip. Thorax brown tinged with red, hind corners of mesonotum yellow. Femora, trochanters and coxae brown, tinged with yellow; tibiae and tarsi black. Wings brownish fumose, darker along costa. The costa extends halfway between the tips of veins R_{4+5} and M_{1+2}. Abdomen brown.

Length: body, 7.5 mm; wings, 8.0 mm.

Philia nigrostigma (Walker)

Bibio nigrostigma Walker, 1848, List Dipt. Ins. Brit. Mus. 1:121.
Bibio zealandicus Walker, 1858, Trans. Ent. Soc. Lond. (n. s.) 4:235.

A male and a female of the type series from New Zealand are in the British Museum; a holotype has not been designated. This is a *Philia* and has been correctly placed in the literature. Refer to Hardy (1951a:268 and 1953:517) for a complete description of this species.

B. zealandicus Walker has been treated as a variety of *nigrostigma,* distinguished from the typical form by having the abdomen of the female ferrugineous below instead of black. I have studied large series of specimens from New Zealand and have found the coloration so variable that it is not practical to consider this as a variety. The type of *B. zealandicus* is probably lost, there is no record of it in the British Museum collection.

Philia serraticollis (Walker)

Dilophus serraticollis Walker, 1848, List Dipt. Ins. Brit. Mus. 1:117.
Dilophus obesulus Loew, 1869, Berl. Ent. Zeits. 13:122. Questionable synonym.

Four specimens are in the collection, one female labeled "type" and three males labeled "one of Walker's series so named." I did not relax and clear the male genitalia but feel quite sure that this is the same as *P. obesula* (Loew). The stigma are faint or lacking in the males and the posterior veins are concolorous with the wing membrane. The genitalia (undissected) seem to fit my concept of this species. Also all other details fit the descriptions which I have given in other places (Hardy, 1945:505 and in press).

Philia spinipes (Say)

Dilophus spinipes Say, 1823, Journ. Acad. Nat. Sci. Phil. 3:79-80.
Plecia bimaculata Walker, 1856, Insecta Saunder. 1:422. New synonymy.

Walker's *Plecia bimaculata* has been unidentifiable (even to genus) from the original description. A male specimen is in the British Museum labeled *"bimaculata"* by Walker. The locality label is not clear, it seems to be "U.S." and this specimen is probably Walker's type although it is not labeled as such. The specimen is in poor condition, the abdomen and wings are missing but there is no question of its being identical with *Philia spinipes* (Say).

Philia tridentata (Walker)

Dilophus tridentatus Walker, 1848, List Dipt. Ins. Brit. Mus. 1:118.
Dilophus africanus Becker, 1903, Mitt. Zool. Mus. Berl. 2:79. New synonymy.

The type female (from Tripoli) is in the collection. Also one female specimen, not from type series, labeled "Mesopotamis: near Baghdad, Himaidicantts, II. 1222 (Major J. E. M. Boyd)".

The literature has been completely misleading with regard to this species. As indicated in my key to African *Dilophus* (Hardy, 1951b:74) *tridentata* has supposedly been characterized by having three sets of double spines above the apical set and the species has been known under the name *Philia africana* (Becker).

P. tridentata is differentiated from other *Philia* by the elongated rostrum, the sclerotized portion of the head beyond the eyes is slightly longer than the antennae and approximately equal in length to the remainder of the head; by the all dark brown to black coloration and by the arrangement of the spines on the front tibiae. The thorax and head are entirely polished black and the abdomen is dark brown to black tinged with reddish brown. The coxae, trochanters and femora are black, faintly tinged with brown and the tibiae and tarsi are dark brown. Each front tibia has six rather short, blunt spines at apex plus the black spur which is about twice the size of one of the spines. It also has two strong spines situated just slightly below middle of segment on a slight prominence and two more strong spines situated on a slight prominence almost at the base of the segment. The portion of the head behind the eyes is approximately two-thirds the length of the eye (female). The halteres are yellow. The wings are predominantly hyaline, just faintly yellowish fumose; the stigma is pale brown. The anterior veins are brown, the posteriors are almost concolorous with the wing membrane.

Length: body, 5.0 mm; wings, 4.8 mm.

Philia zealandica (Walker)

Bibio zealandicus Walker, 1858, Trans. Ent. Soc. Lond. (n. s.) 4:235.

The type is not present in the British Museum collection and has probably been lost. This is a synonym of *P. nigrostigma* (Walker), see discussion under that species.

Bibio bicolor Walker

Bibio bicolor Walker, 1848, List Dipt. Ins. Brit. Mus. 1:121.

Described from a female from the East Indies. I evidently overlooked this specimen in the British Museum but Paul Freeman has kindly examined it and has reported by correspondence that "the entire thorax and all coxae are red; the mesonotum has rather coarse but not particularly long pubescence (golden). The front tibia has one spine broad and striated and the other much reduced. We have only the single female type and there does not seem to be anything else belonging to the same species in the collection. Our *?plecioides* have black coxae and the thoracic pubescence seems to be longer and not quite so coarse." I had suggested that *B. plecioides* Osten Sacken, 1881, might possibly be a synonym since from the original description it could not be differentiated. *B. bicolor* is obviously related to *B. imitator* Walker but apparently differs by having the abdomen black.

Bibio fumipennis Walker

Bibio fumipennis Walker, 1848, List Dipt. Ins. Brit. Mus. 1:122.
Bibio inaequalis Loew, 1864, Berl. Ent. Zeits. 8:51. New synonymy (also reported by Hardy, in press).

Two male specimens are in collection from St. Martin's Falls. Albany River, Hudson Bay, one is labeled "type." This is quite obviously the same as *B. inaequalis* Loew and bears out my contention that these were based upon slight variations in the leg coloration. The legs of the type are all rufous, in other specimens I have examined some or all of the femora and tibiae are dark tipped. The inner spur of each front tibia is short, the hind basitarsus is swollen and the front femur is stout. The thoracic pile is all yellow. The wings are rather intensely yellow fumose, the posterior veins are concolorous with the membrane and crossvein r-m is equal in length to the base of the radial sector.

Bibio gracilis Walker

Bibio gracilis Walker, 1848, List Dipt. Ins. Brit. Mus. 1:123.

Preoccupied by *B. gracilis* Unger, name changed to *B. slossonae* Cockerell, see discussion under that species.

Bibio humeralis Walker

Bibio humeralis Walker, 1848, List Dipt. Ins. Brit. Mus. 1:121.

Synonym of *B. xanthopus* Wiedemann, see under that species.

Bibio imitator Walker

Bibio imitator Walker, 1834, Ent. Mag. 2:470.
Bibio substituta Walker, 1848, List Dipt. Ins. Brit. Mus. 1:121.

The type of *Bibio imitator* Walker is apparently lost, there is no record of it in the British Museum collection. *Bibio substituta* Walker is represented in the collection by seven females, these fit my concept of *imitator* by being entirely yellow to rufous with dark brown to black legs, except for the yellow coxae.

Both of these species were described from "New Holland" and I am convinced that they are synonyms. Walker's description of *imitator* was

quite adequate for recognizing the species; this is the only species of *Bibio* definitely known from Australia. *B. fulvipennis* Macquart, 1850; *B. ruficoxis* Macquart, 1850; *B. elegans* Jaennicke, 1867 and *B. helioscops* Schiner, 1868 are apparently all synonyms of *imitator*.

Bibio scita Walker

Bibio scita Walker, 1848, List Dipt. Ins. Brit. Mus. 1:122.

Synonym of *B. xanthopus* Wiedemann, see under that species.

Bibio slossonae Cockerell

Bibio slossonae Cockerell, 1909, The Entomologist 42:174. Change of name for *Bibio gracilis* Walker.
Bibio gracilis Walker *(nec* Unger), 1848, List Dipt. Ins. Brit. Mus. 1:123.

Six male specimens of *gracilis* are in the collection, each labeled "one of Walker's series so named" and one contains a type label. This species has been correctly interpreted in our literature. Walker's name is preoccupied by *Bibio gracilis* Unger.

In the type the inner spur of the front tibia is short, the hind basitarsus is swollen, about three times longer than wide and the legs are all dark colored. The pile of the mesonotum, abdomen, and legs is black.

Bibio striatipes Walker

Bibio striatipes Walker, 1848, List of Diptera Ins. Brit. Mus. 1:122-123.
Bibio conus Hardy, 1938, Can. Ent. 70:208. New synonymy.

The type male, from St. Martin's Falls, Albany River, Hudson Bay, is in the collection. The species has not been recognized since the original description until the type was studied by Mr. G. E. Shewell (Canadian Department of Agriculture, Ottawa) the summer of 1951. He found that *Bibio conus* Hardy (1938:208) is a synonym. I have confirmed this and have reported upon this in my Bibionidae of Connecticut (Hardy, in press).

B. striatipes fits close to *xanthopus* Wiedemann. The males are distinguished by the somewhat swollen hind tarsi, with very short basitarsi and by the posterior veins of the wing being concolorous with the wing membrane. The short, thick head of the female as discussed in the above reference will distinguish specimens of this sex.

Bibio substituta Walker

Bibio substituta Walker, 1848, List Dipt. Ins. Brit. Mus. 1:121.

The type and six other females are in the collection from "New Holland." This is evidently a synonym of *B. imitator* Walker, see discussion under that species.

Bibio vestita Walker

Bibio vestita Walker, 1848, List Dipt. Ins. Brit. Mus. 1:122.
Bibio nervosus Loew, 1864, Berl. Ent. Zeits. 8:52. New synonymy.

The type series of four males, from Nova Scotia are in the collection; one is labeled type. This species has never been correctly placed in the literature. It has been assumed, following McAtee's discussion (1921:15) that

the inner spur of the front tibia is short and that it fits near *fumipennis* Walker and *striatipes* Walker. The inner spur actually is elongate, almost equal in length to the outer. It is quite obviously the same as *nervosus* Loew. The femora are all black, except for a tinge of red on the basal halves of the hind pair. The tibiae are predominantly rufous and the hind basitarsi are slender. The thoracic pile is dense black. The posterior veins of the wing are nearly hyaline, concolorous with the membrane and the r-m crossvein is equal in length to the base of the radial sector.

Bibio xanthopus Wiedemann

Bibio xanthopus Wiedemann, 1828, Aus. Zweifl. Ins. 1:80.
Bibio humeralis Walker, 1848, List Dipt. Ins. Brit. Mus. 1:121. Confirmation of previously questionable synonymy.
Bibio scita Walker, 1848, List Dipt. Ins. Brit. Mus. 1:122. Confirmation of synonymy.

One female specimen of *Bibio humeralis* is labeled "type," it also has Austin's note that this was "one of Walker's series so named." It is a female specimen of *B. xanthopus* Wied. In my revision of the Nearctic Bibionidae (Hardy, 1945:491) I had placed this as a synonym of *xanthopus* with a question.

Bibio scita Walker is represented in the collection by the type female and six males and five females from the original series. These specimens show considerable variation in the length of the inner spur of the front tibia. In some females it is nearly three-fourths as long as the outer and shows integradation toward *vestita* Walker. In the males the inner spur is approximately half as long as the outer, in one specimen the inner spur is very short on one tibia and moderately elongate on the other. In body coloration and vestiture the series are typically *xanthopus* and I feel there is no question of its being a synonym. The comparative lengths of the tibial spurs seems much less reliable for distinguishing *xanthopus* than for any other known species of *Bibio*.

LITERATURE CITED

Duda, O. 1930. Bibionidae: In Lindner, Die Fliegen der Palaear. Reg. 4:1-72.
Hardy, D. E. 1938. New Bibionidae from British Colombia. Can. Ent. 70:208.
Hardy, D. E. 1945. Revision of Nearctic Bibionidae, including Neotropical *Plecia* and *Penthetria* (Diptera). Univ. Kans. Sci. Bull. 30(2):367-547.
Hardy, D. E. 1951a. Studies in Pacific Bibionidae. Part II. Genus *Philia* Meigen. Proc. Haw. Ent. Soc. 14(2):257-275.
Hardy, D. E. 1951b. A monographic study of the African Bibionidae (Diptera). Part II. Genus *Philia* Meigen. Journ. Kans. Ent. Soc. 24(2-3):74-94.
Hardy, D. E. 1953. The Bibionidae of New Zealand. Pac. Sci. 7(4):513-521.
Hardy, D. E. In press. Guide to the Insects of Connecticut. The Diptera or True Flies of Connecticut. Seventh fascicle. Bibionidae.
McAtee, W. L. 1921. Notes on Nearctic bibionid flies. Proc. U. S. Nat. Mus. 60(11):1-32.

MORPHOLOGY OF THE THORACIC EXOSKELETON AND MUSCULATURE OF A MAYFLY *SIPHLONURUS COLUMBIANUS* McDUNNOUGH (Siphlonuridae, Ephemeroptera), A contribution to the subcoxal theory of the insect thorax[1]

RYUICHI MATSUDA

INTRODUCTION

So far as the writer is aware the first noteworthy morphological work on the thorax of an adult mayfly is that of Dürken. Dürken, in his attempt to homologize the muscles of the abdominal gills with the wing muscles of the pterothorax, worked on the external structure and musculature of *Centroptilum luteolum* and *Ephemerella ignita*. Dürken's work was immediately refuted by Börner (1908). Börner, applying his theory of the subcoxal origin of the leg base in the Arthropoda (1904), came to the conclusion that the abdominal gills are homologous to the thoracic legs which is contrary to Dürken's conclusion that the abdominal tracheal gills in the mayfly are of tergal origin. This controversy lasted until Dürkin published his work on the postembryonic development of the tracheal gills in the mayfly abdomen (1923). Börner succeeded in pointing out, at least, the insufficiency of Dürkin's data as to the ventral attachement of one morphologically important dorso-ventral muscle.

Later, Takahashi (1932), Knox (1935), and Maki (1938) worked on the thorax of the adult mayflies, but their works do not touch the problem of the subcoxal origin of the pleuro-sternal region of the thorax with which the present study is primarily concerned. Knox's work on *Hexagenia recurvata* and Maki's work on *Ecdyonurus hyalinus* are, however, referred to in this study for their apparent reliability in anatomical data.

Grandi (1941, 1942) briefly described the external structure of *Caenis macrura* and *Choroterpes pictei*. Grandi (1947) further studied the muscles associated with the axillary sclerites in a series of species of Ephemeroptera and came to the conclusion that the axillary sclerites in this order are not homologous to those in other orders of pterygote insects.

As already noted, Börner was the first to apply the concept of the subcoxal origin of the pleuro-sternal region of the insect thorax to this order, but his interest was apparently in the origin of the abdominal tracheal gills, and what he actually worked out and interpreted by himself was the thorax of the nymph. Moreover, the subcoxal theory has undergone changes in its details since Heymons (1899) first postulated the theory on the basis of embryological evidence as was recently reviewed by Matsuda (1956).

The present study is, primarily, an attempt to interpret the pleuro-sternal region of the adult thorax of this more or less strongly divergent group, the order Ephemeroptera, in terms of the subcoxal theory as interpreted by Ferris (1939) which is being steadily accepted in recent years.

[1] Contribution No. 922, Department of Entomology, University of Kansas.

The genus *Siphlonurus* on which the present study is based is admittedly the most primitive group existing in the order Ephemeroptera. This excellent material will provide more authentic anatomical data for morphological consideration than any other groups that have been worked out by previous workers.

The specimens were collected at Tuolumne Meadow, Yosemite National Park, California by the writer during his stay in that park from June to August, 1955.

ACKNOWLEDGMENTS

The writer wishes to express thanks to Professor Kathleen Doering, University of Kansas, for her valuable criticism, and to Professor G. F. Edmund, University of Utah, for the identification of specimens.

EXTERNAL MORPHOLOGY

THE PROTHORAX

(Plate 1, A, B)

The pronotum: The pronotum is a transverse simple plate hanging laterally over the subcoxa, and connected with the latter by a folded membranous area. There is an elongate strongly sclerotized area on either side of the median longitudinal axis for the attachment of muscles.

The subcoxa: The subcoxa is distinctly divided into anterior episternal and posterior epimeral regions by the pleural suture. The episternal region exposed outwardly is the anepisternum. There is also a narrow sclerite along the inner margin of the coxal base. This sclerite is the katepisternum, and is articulated with the coxal margin. No previous authors described this narrow sclerite. This is apparently the ventral part of the inner ring of the subcoxa homologous to the katepisternum in the pterothorax of this species and in Neuroptera. The validity of this interpretation is further demonstrated by the attachment of the homologous muscle with the notokatepisternal muscle in the pterothorax on this sclerite. There is present no trochantin in the prothorax. The procoxa has, thus, dicondylar articulation with the subcoxa, namely, with the ventral end of the pleural suture and with the apex of the katepisternum.

The prosternum: The basisternum is well developed antero-laterally extending almost to the ventral end of the anepisternum; laterally the basisternum is clearly separated from the subcoxa by membranous area; posteriorly the basisternum is indistinguishably fused with the furcasternum. The sternal apophysis is vertically erected and its presence is recognizable externally by the presence of a pit, the sternal apophyseal pit. There is no differentiation into the presternite and postfurcasternite in this species.

The cervical sclerites: The cervical sclerites are composed of a pair of narrow plates, which are articulated posteriorly with the antero-lateral angle of the anepisternum, and anteriorly with the lower lateral angle of the postoccipital ridge.

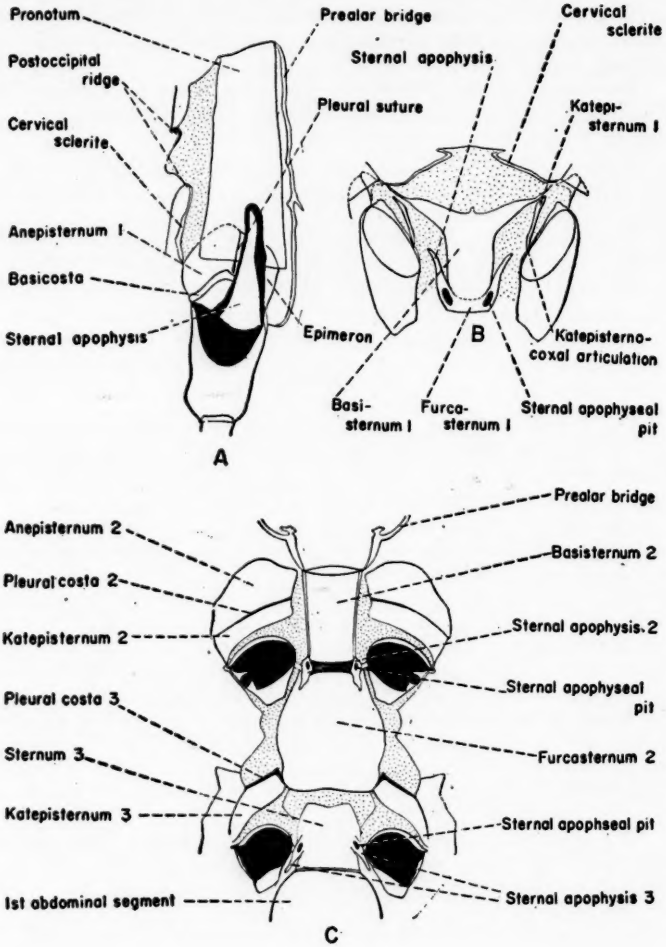


PLATE 1

A. Prothorax, lateral view.
B. Prothorax, ventral structure, seen from above (notum removed).
C. Pterothorax, ventral structure, seen from above (notum removed).

THE MESOTHORAX

(Plate 1, C; Plate 2, A, B)

The mesonotum: The mesonotum is divided into the following regions: The acrotergite, the prescutum, the scutum, the scutellum, and the postnotum. The acrotergite extends latero-ventrally to form the prealar bridge. The prealar bridges are united ventrally foming a complete ring in the anteriormost region of the mesothorax. The prescutum is anteriorly united with the antecosta at the point where the prealar bridge differentiates latero-ventrally, and forms an inflection for the attachment of the dorsal longitudinal muscle. The scutum is the largest part of the mesonotum forming a characteristic round protuberance. The posterior parapsidal suture extends anteriorly to fuse with the prescutal suture. The lateral margin of the scutum bears a narrow and concave anterior notal process to articulate with the first axillary sclerite. The scutellum is marked off from the lateral margin of the scutum by the scuto-scutellar suture which makes a curve upward close to the midline, the suture does not entirely set off the scutellum from the scutum in the mid-dorsal region. Laterally the scutellum bears the posterior notal process. The postnotum is represented by a narrow transverse sclerite lying beneath the scutellum. The large phragma arising from the postnotum projects downwardly into the thoracic cavity and fuses laterally with the mesepimeron; posteriorly the phragma arising from the postnotum is continuous with the phragma arising from the anterior margin of the metanotum. No development of well sclerotized postnotum is seen in this order.

The subcoxa: In the mesothorax of this primitive species two subcoxal rings, namely the ana- and katapleural rings are clearly recognized. The well sclerotized, depressed suture running dorso-posteriorly from the ventral surface in front of the coxal base is apparently the pleural costa of Ferris which demarcates the katapleural ring from the anapleural ring. The pleural costa ventrally reaches near the middle of lateral margin of the basisternum, it dorsally extends into the epimeral region after it meets with the pleural suture arising upwardly from the point of articulation between the subcoxa and the coxa, thus the mesepimeron is divided into the upper anepimeron and lower katepimeron. The pleural suture which Knox (1935) failed to recognize in *Hexagenia recurvata* is fine but distinct in this species. The anapleural ring in the episternal region which is represented by the area above and anterior to the pleural costa is not divided into the upper and lower areas by a suture as in Neuroptera. The basalar sclerite is well marked and located in front of the pleural wing process. It is articulated with the tegula, and the tegula, in turn, is articulated with the humeral plate of the wing. There is no trochantin in the katepisternal region in this order. The katepisternum extends ventrally near to the lateral margin of the basisternum. The subcoxa, both ana- and katapleural rings, is clearly separated from the sternum ventrally. The epimeral region is largely membranous, but the well sclerotized large subalar sclerite is present above the pleural costa. The subalar sclerite is provided with an apodeme inwardly, the presence of this apodeme is externally recognizable

by the presence of a pit. The totally membranized postcoxal bridge borders ventrally the furcasternum. There is, thus, only one point of articulation between the subcoxa and the coxa in the mesothorax.

The ordinary three axillary sclerites are clearly recognizable, each sclerite maintains the typical topographical position in relation to the other axillary sclerites and to the anterior and posterior notal processes as is exemplified by Snodgrass (Principles of insect morphology, p. 219). The first axillary sclerite is articulated with the anterior notal process and the second axillary sclerite. The third axillary sclerite is anteriorly articulated with the second axillary sclerite and posteriorly with the base of the posterior notal process. Each sclerite, however, has no particular relationship with the base of a particular wing vein due to the strong development of the region corresponding to the median plate in other orders of pterygote insects as Grandi (1947) contends. Grandi apparently failed to recognize the presence of the third axillary sclerite in a series of species she examined, and she proposed the names Pseudopteralia 1, 2, 3, referring each to the first, second sclerites and the basal part of the median plate. The present writer will again discuss this problem in the discussion of the musculature associated with these sclerites.

The mesosternum: The mesosternum is clearly divided into two regions, the furcasternum and the basisternum. The division of these two regions is marked by the position of the sternal apophysis and the suture connecting both apophyses. The furcasternum is well developed and concave to receive the subalar-furcasternal muscle. The pleural costa of the metathorax reaches the posterolateral angle of the furcasternum. The basisternum is the region anterior to the sternal apophyses, elongate and much narrower than the furcasternum. The sternal apophyses are well marked externally by small pits (sternal apophyseal pit). The apophysis is connected with the inner margin of the coxa by a weak membrane. The pleural apophysis is absent in this species.

THE METATHORAX

(Plate 1, C; Plate 3, A, B, C)

The metanotum: In the metanotum a recognizable prescutum is not differentiated on the anterior margin. The phragma directly develops from the anterior margin of the scutum, the phragma goes first upwardly then abruptly downwardly to connect with the phragma arising from the postnotum beneath the mesothoracic scutellum. The scutum is not subdivided by ridge or the parapsidial suture as in the mesothorax; the anterior notal process on the lateral margin of the scutum is represented by a small concave sclerite. The scutellum is the region posterior to the scutum, the division between the scutum and the scutellum is rather obliterated. A concave postnotal process arises from the anterior end of the lateral margin of the scutellum. The postnotum is attached on the undersurface of the scutellum and is developed laterally so that it fuses with the epimeron, posteriorly it is inclined and distinctly bordered by the anterior margin of the first abdominal segment.

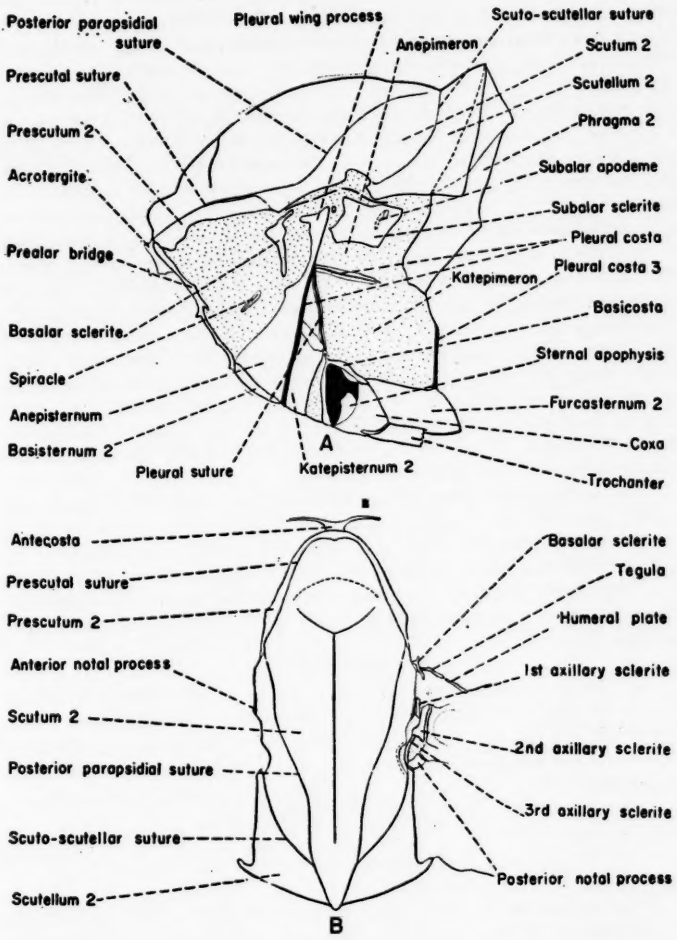


PLATE 2

A. Mesothorax, lateral view.
B. Mesothorax, dorsal view.

The subcoxa: The subcoxal region in the metathorax is characterized by its strong reduction of the anapleural ring. Otherwise the organization of the subcoxal wall is essentially the same as in the mesothorax. The pleural costa ventrally reaches the postero-lateral angle of the mesothoracic furcasternum, dorsally the suture meets with the pleural suture which is represented by a rather weak suture arising from above the coxal condyle. The area bounded by the pleural costa, the pleural suture, and the anterior margin of the coxa is apparently homologous to the katepisternum in the mesothorax. The katepisternum, as in the mesothorax, lacks the trochantin and the area along the anterior coxal margin is widely membranized. The anapleural ring is represented by the membranized region enclosing the spiracle anterior to the pleural costa and the upper part of the pleural suture. There is no development of the postcoxal bridge in the metathorax. The epimeron is indistinguishably fused with the postnotum. There is no sclerotized basalar sclerite in the metathorax. The subalar sclerite is small and oblong, located behind the pleural process. The hind wing is articulated anteriorly with the membranous area in front of the sclerotized antero-lateral angle of the scutum. There is only one well sclerotized axillary sclerite which is apparently homologous to the second axillary sclerite judging from the muscle attachment and from the position in relation to the median plate. This sclerite, however, is articulated with the anterior notal process which is small and concave.

The metasternum. The metasternum is represented by a single plate located posterior to the mesofurcasternum with the intervention of the membranous region between them. There is no clear subdivision of this plate into the basi- and furcasternum. The location of the sternal apophyses are recognizable externally by the presence of the sternal apophyseal pits. The metasternum is posteriorly bordered by the sternum of the first abdominal segment.

THE COXA

The basicoxite in all three thoracic segments is well developed on outer margin of the coxa. There is no development of the secondary meron (Larsen, 1945) in this species. Also there is no conspicuous development of the trochanteral apodeme intruding into the coxa seen in other orders of insects.

THE MUSCULATURE

THE PROTHORAX

(Plate 4, A, B, C; Plate 7, B)

Muscles inserted on the cervical sclerites: There are three muscles that are inserted on the cervical sclerite. The first one is an oblique thick muscle arising from the heavily sclerotized portion of the pronotum and is inserted on the upper tip of the cervical sclerite (1). The second thin muscle connects the upper lateral angle of the postoccipital ridge and the lower tip of the cervical sclerite (2). The third fine muscle extends between the sternal apophysis near tip and the cervical sclerite near tip (3). Knox (1935) shows five muscles attached on the cervical sclerite.

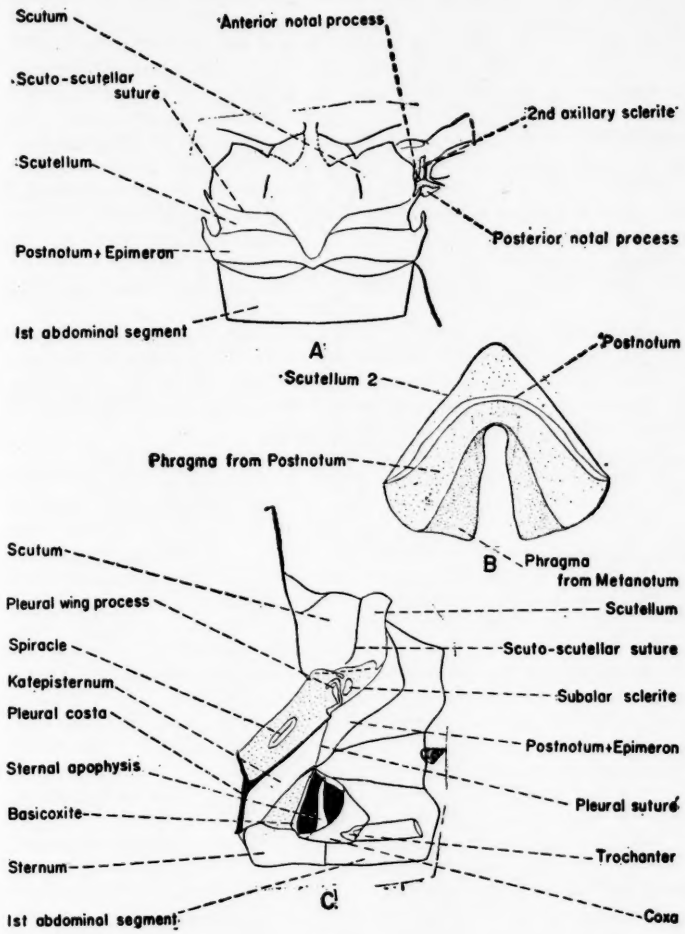


PLATE 3

A. Metathorax, dorsal view.
B. Phragma between the meso- and metathorax.
C. Metathorax, lateral view.

Dorsal muscles: There are seven dorsal muscles. Three of them are attached on the upper lateral angle of the postoccipital ridge, one coming from the pronotum on anterior margin at middle (4), one from the pronotum near posterior margin at middle (5), and the third from the prealar bridge at base (6). The fourth thick and oblique muscle extends between the antecosta of the mesothorax and the pronotum near median longitudinal axis (7). The fifth rather slender muscle extends between the posterior end of the oblong strongly sclerotized region of the pronotum and the prealar bridge above the middle (8). The sixth very short muscle is superposed on the preceding muscle between the prealar bridge and near posterior margin of the pronotum (9). The seventh slender oblique muscle stretches between the prealar bridge above the attachment of the preceding muscle and the anterior margin of the pronotum at middle (10). Both Maki (1938) and Knox (1935) have described only three muscles.

Longitudinal muscles attached on the postoccipital ridge: There is one very fine muscle extending between the upper lateral angle of the postoccipital ridge and the anterior angle of the anepisternum (11). Another fine longitudinal muscle extends between the postoccipital ridge and the antero-lateral margin of the basisternum (12).

Noto-subcoxal muscles: There is one wide but very thin muscle which arises from near the lateral margin of the pronotum and is inserted on the upper margin of the subcoxa including both the episternal and epimeral regions (13). There is another muscle originating from the pronotum below the oblong heavily sclerotized area which is inserted on the anterior margin of the katepisternum (14). Knox (1935) did not show either one of these muscles. Maki's (1938) first tergal abductor of the coxa (16) is probably the noto-katepisternal muscle in this species.

Noto-coxal muscles: Two slender muscles originating from near the lateral margin of the pronotum insert on the posterior basicosta near posterior angle (15, 16). The third slender, oblique muscle originating from above the origin of the preceding muscles are inserted on the basicosta beneath the insertion of the preceding muscles (17). The fourth slender muscle originating from the pronotum anterior to the origin of the preceding muscle (17) goes obliquely cephalad to insert on the anterior angle of the basicosta (18).

Subcoxo-coxal muscle: One rather broad but thin muscle originating from near the upper margin of the anepisternum is inserted on the antero-lateral part of the basicoxite (19).

Trochanteral muscles: One slender muscle originating from near the origin of the posterior noto-coxal muscles is inserted on the anterior tip of the trochanter (20). Another muscle originating from the subcoxa in the epimeral region inserts on the trochanter (21). Another muscle arising from the coxal margin beneath the coxal muscle inserts on the trochanter (22). Maki (1938) does not give the noto-trochanteral muscle.

Sterno-coxal muscles: One fine muscle connects the base of the sternal apophysis and the coxal margin beneath the point of insertion of the

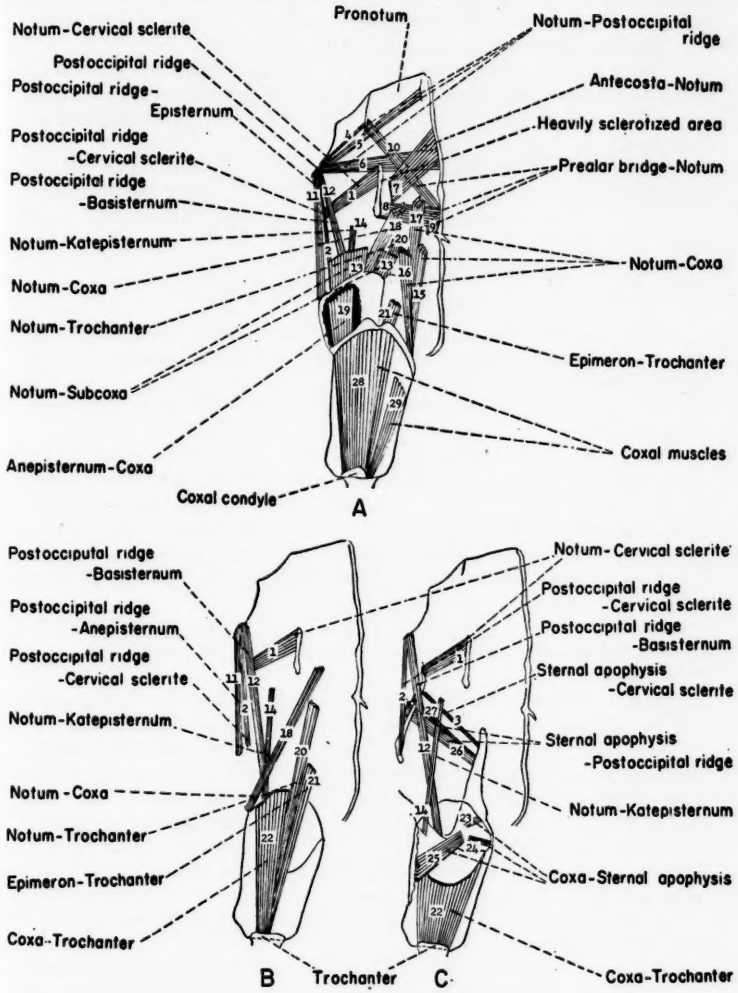


PLATE 4

Muscles of the prothorax.

posterior noto-coxal muscles (23). Another small muscle connects the inner posterior margin of the coxa and the base of the sternal apophysis (24). A rather strong muscle originating from near outer anterior margin of the coxa attaches on the base of the sternal apophysis (25).

Ventral muscles: There are two fine muscles connecting the sternal apophysis and lower postoccipital ridge inside the point of articulation with the cervical sclerite (26, 27). One of them is thicker and superposed on the other.

Coxal muscles: Two muscles arising on the coxal wall insert on the coxal condyle. The anterior one arises from the anterior upper coxal margin (28), and the posterior small one from near the postero-lateral angle of the coxa (29).

THE MESOTHORAX

(Plate 5, A, B; Plate 6, A, B; Plate 7, A, B)

Dorsal muscles (Plate 5, A ,B): The median dorsal muscle is a huge muscle occupying two thirds of the median axis of the mesothorax when viewed laterally (30). The oblique dorsal muscle originates from the scutum in front of the scutoscutellar suture and inserts on the mesophragma (31).

Noto-coxal muscles (Plate 5, A and Plate 6, B): One thick muscle arising from the scutum anterior to the posterior parapsidal suture inserts on the anterior coxal margin (32). Two other vertical muscles arising along the posterior parapsidal suture insert on the posterior coxal margin (33, 34). A fine muscle coming from the scutellum near its lateral margin is continuous with the connective tissue arising from the inner posterior angle of the coxa (35).

Pleural costa-coxal (Katapleuro-coxal) muscle (Plate 5, B): The katapleuro-coxal muscle arises from the pleural costa and inserts on the anterior basicoxite (36).

Subalar muscles (Plate 5, B and Plate 6, B): There are three muscles originating from the subalar sclerite. The subalar-coxal muscle arises from the anterior portion of the subalar sclerite and inserts on the posterior basicoxa (37). The subalar furcasternal muscle is a robust muscle arising from almost the entire surface of the subalar sclerite. It is twisted posteriorly and is inserted ventrally practically on the entire surface of the furcasternum (38). The third muscle is fine, coming from the apodeme of the inner wall of the subalar sclerite and inserts on the tip of the sternal apophysis (39). Dürken (1907) describes a muscle between the apodeme of the subalar sclerite (?) (Zapfen des Epimerum) and the mesonotum in *Ephemerella ignita.*

Basalar muscles (Plate 6, B): There are three muscles that are attached on the basalar sclerite. One muscle goes obliquely between the upper margin of the basalar sclerite and the upper anterior margin of the prothoracic sternal apophysis (40). Another slender muscle connects the lower tip of the basalar sclerite and the prothoracic sternal apophysis on posterior margin near tip (41). The last muscle is a fine muscle coming from the

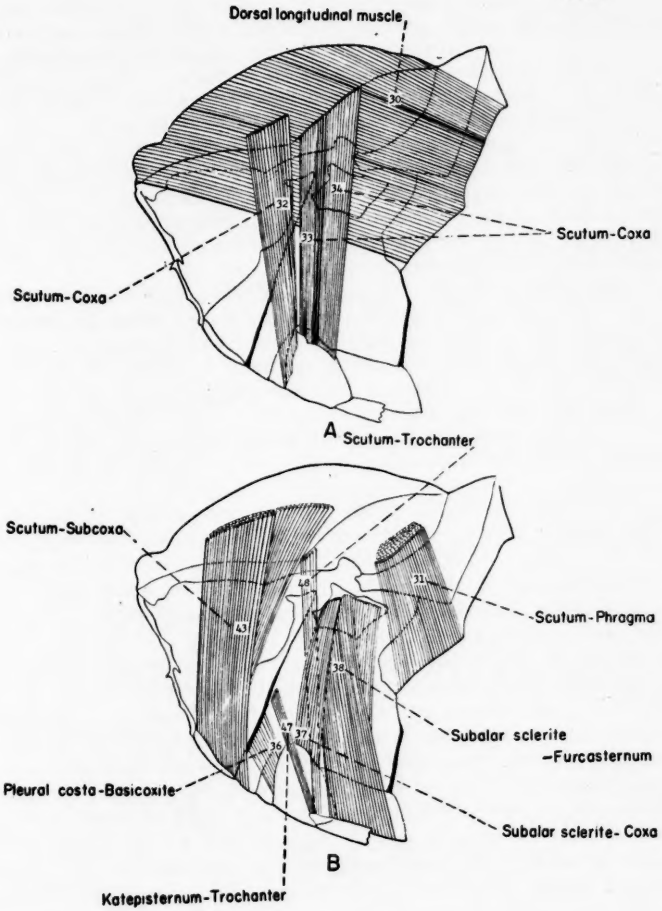


PLATE 5

Muscles of the mesothorax.

pleural wing process and attaches on the basalar sclerite at the point where this sclerite is articulated with the tegula (42).

The first two muscles are Grandi's *muscolo prosterno-basalare dorsale* and *muscolo prosterno-basalare ventrale*. These two muscles seem to be different in the ventral point of attachment in different species. Grandi (1947) says, *"Essi si dirigono parallelemente in avanti e raggiungono la regione posteriore laterale del prosterno ove si attacano a due piccole prominenze piu o meno sclerificate e distinte nelle diverse specie."* Knox (1935) describes the homologous muscle as attaching ventrally on the furcilla of the prothoracic postfurcisternum. Maki (1938) says that they are attached on the antero-lateral corner of the sternum. The last mentioned muscle (42) is very probably Grandi's *muscolo pleurocondilo-scutale*. If so, this muscle also shifts its dorsal point of attachment in different species within the same order. Maki (1938) describes the basalar-coxal muscle. The present writer did not find this muscle.

Noto-subcoxal muscles (Plate 5, B and Plate 6, B): A very robust muscle arising from the lateral area of the scutum before the posterior parapsidial suture inserts on the ventral margin of the anepisternum and the katepisternum (43). The second muscle is a slender one connecting obliquely the lateral margin of the sclerotized part of the anepisternum and the prescutum near the anterior end (44). The third muscle is also a slender muscle connecting the anterior margin of the anepisternum above the attachment of the preceding muscle and the scutum anterior to the anterior notal process (45).

The first muscle (43) is usually called the anterior tergo-sternal muscle. The primitive point of ventral attachment of this muscle in insects was already discussed by Matsuda (1956), and it was considered to be secondary when this muscle is attached to the basisternum. Knox's data (1935) on the ventral attachment of this muscle is obscure. Judging from his description and figures of mesosternum (Plate 23, fig. 2), the area he designates as the ventral point of insertion is not necessarily the basisternum. The same thing happened when Börner (1908) pointed out the imprecision of Dürken's data as to the ventral attachment of this muscle. Börner confirmed that this muscle was the tergo-subcoxal muscle (Noto-subcoxal muscle). Maki gives two anterior tergo-sternal muscles and he says that their ventral point of attachment is the sternum, but as the present writer (1956) already pointed out and cautioned, Maki very often was confused as to the morphological assignment of the ventral sclerites when he wrote his big monograph. Anyhow this muscle is clearly inserted on the ventral end of the subcoxa, at least, in *Siphlonurus columbianus*. Knox (1935) does not describe the second muscle (44).

Trochanteral muscles (Plate 5, B and Plate 7, A): A slender muscle arising from the katepisternum anterior to the point of union between the pleural costa and the pleural suture inserts on the tip of the trochanter (47). Noto-trochanteral muscle originates from the scutellum near lateral margin a little behind the posterior parapsidal suture (48). One muscle

arising along the inner coxal margin inserts on the apical region of the trochanter (49).

Knox (1935) describes one muscle from the basalar sclerite to the trochanter. Dürken (1907) describes a muscle from the sternal apophysis to the postero-inner margin of the trochanter in both *Centroptilum* and *Ephemerella*. These muscles were not found in *Siphlonurus columbianus*.

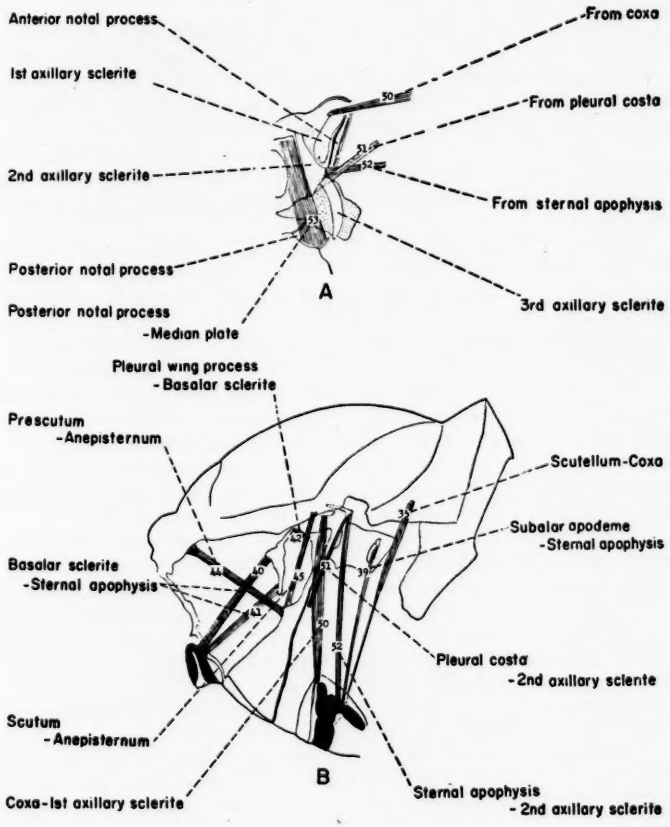


PLATE 6

A. Muscles inserted on the axillary sclerites (Mesothorax).
B. Muscles of the mesothorax.

Muscles of the axillary sclerites (Plate 6, A, B): The first one is a cylindrical muscle extending between the first axillary sclerite and the coxal process (50). Two muscles are attached on the second axillary sclerite. One of them extends between the pleural costa below the point of union with the pleural suture and the posterior margin of the second axillary sclerite where the third axillary sclerite is articulated (51). The other muscle extends between the second axillary sclerite at inner posterior angle and the tip of the sternal apophysis (52). There is a fourth muscle that stretches between the posterior notal process and the base of the median plate (53).

The first muscle (50) seems to vary in its dorsal point of attachment. Knox (1935) says that it dorsally attaches on the basalar sclerite. Maki (1938) found it inserted on the anterior portion of the first axillary sclerite. Grandi (1947) says, "*. . . si inserisce da una parte al meron e dall'altra al limite fra scuto e regione ascellare, davanti all'inflessione ascellare.*"

As to the third muscle extending between the sternal apophysis and the second axillary sclerite (52) Grandi says, "*. . . inserzione dorsale sia il margine dello scuto, subito dietro l'inflessione ascellare, sia il secundo pseudopterale.*"

No previous workers, including Grandi (1947) who has worked on this particular problem in five families of Ephemeroptera, found the muscle extending from the pleural costa to the posterior margin of the second axillary sclerite where the third axillary sclerite is articulated (51). This muscle shows a striking similarity to the wing flexor muscle in other pterygote insects which usually inserts on the third axillary sclerite.

Coxo-sternal muscles (Plate 7, A): Three small muscles arising on the coxal wall insert on the sternal apophysis. One arising from near posterior angle of the coxa inserts on the apical portion of the sternal apophysis (54). One muscle arising from beneath the coxal process inserts on the apex of the sternal apophysis (55). One muscle from the inner anterior angle of the coxa inserts on the basal region of the sternal apophysis (56).

Ventral muscles (Plate 7, A, B): The ventral longitudinal muscle is a slender muscle connecting the prothoracic sternal apophysis and the mesothoracic sternal apophysis at base (57). The ventral transverse muscle is thickened medially. It arises on each side from the outer posterior coxal wall and connects both legs across the sternum in the area of the mesothoracic ganglion (58). Another transverse muscle is fine, connecting the inner margins of the sternal apophyses at their bases (59).

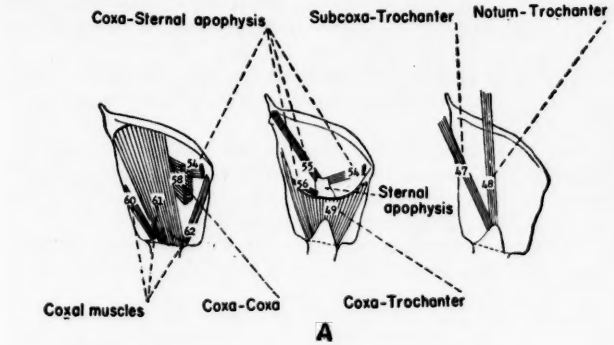
No previous workers have described the transverse muscle that connects the two legs (58).

Coxal muscles (Plate 7, A): Three muscles arising on the coxal wall insert on the coxal condyle. The anterior one arises from the anterior margin (60), the median one from the upper coxal margin (61), and the posterior one from near the postero-lateral angle of the coxa (62).

THE METATHORAX
(Plate 7, B; Plate 8, A, B)

Dorsal muscles (Plate 7, B): The median dorsal muscle is a thick

muscle extending between the mesophragma and the antecosta of the metathorax (63). The dorsal oblique muscle arises from the scutum in front of the scuto-scutellar suture and is inserted on the lateral extension of the postnotum (64).



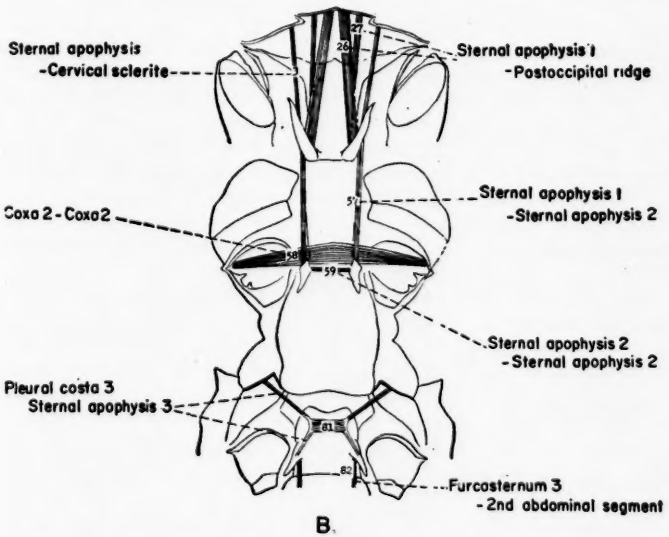


PLATE 7

A. Muscles of mid coxa and trochanter.
B. Ventral muscles.

Noto-coxal muscles (Plate 8, A, B): One muscle arising from near antero-lateral angle of the scutum inserts on the anterior basicosta beneath the insertion of the katapleuro-coxal muscle (65). Another thick muscle originating from near postero-lateral angle of the scutum before the scuto-scutellar suture inserts on the posterior coxal rim (66). A third fine muscle originating on the lateral region of the scutellum right behind the scuto-scutellar suture goes down to connect with the connective tissue arising from the inner posterior angle of the coxa (67).

Pleural costal-coxal (Katapleuro-coxal) muscle: One flat, rather broad muscle originating along the pleural costa inserts on the anterior basicoxite (68).

Subalar muscles (Plate 8, A, B): There is one muscle going from the subalar sclerite to the basicoxa behind the coxal process above partly on the attachment of the posterior noto-coxal muscle (69). Another muscle homologous to the muscle between the subalar apodeme and the sternal apophysis in the mesothorax arises from the posterior region of the posterior notal process (70). This muscle, on its way down, attaches the anterior margin of the first pleural abdominal segment.

Maki's subalar-sternal muscle ventrally attaches to the posterior sternal region fused with the first abdominal segment. Maki (1938) does not show the subalar-coxal muscle. The homologous muscle arises from the unsclerotized chitin between the epimeron and the scutum in *Hexagenia recurvata* according to Knox (1935).

Noto-subcoxal muscles (Plate 8, A, B): One muscle originating from the antero-lateral angle of the scutum inserts along the ventral margin of the sclerotized katepisternum (71). One small muscle arising from the membrane anterior to the origin of the cylindrical muscle between the first axillary sclerite and the coxal process goes to the antero-lateral angle of the scutum (72). A paired exceedingly fine muscle between the membrane near the spiracle goes to the antero-lateral angle of the scutum (73).

Knox (1935) says that his Dvm 1 (71) attaches ventrally on the antero-lateral portion of the furcasternum. Both Maki (1938) and Knox (1935) do not give the last two muscles.

Trochanteral muscles (Plate 8, A, B): The noto-trochanteral muscle originates from the lateral margin of the scutum at middle and inserts on the trochanter intruding into the coxa (74). The subcoxo-trochanteral muscle originates along the pleural costa between the origin of pleural costa-coxal muscle and the point of union with the pleural suture and inserts on the trochanter (75).

Dürken describes a sternal depressor of the trochanter in both *Centroptilum* and *Ephemerella.* This muscle was not found in *Siphlonurus columbianus.*

Axillary muscles (Plate 8, A, B): From the posterior angle of the second axillary sclerite one fine muscle extends obliquely and is attached on the episternum near the pleural costa at the point of union with the pleural suture (76). Another muscle extends vertically and is inserted on

the tip of the sternal apophysis (77). A third subcylindrical muscle extends from the wing base just anterior to the second axillary sclerite to the coxal process (78).

Knox (1935) describes a muscle between the pleuron anterior to the pleural-coxal articulation and the lateral oblique margin of the scutum which is anterior to the notal wing process, and homologizes this muscle with the dorsal basalar-sternal muscle in the mesothorax. Knox (1935)

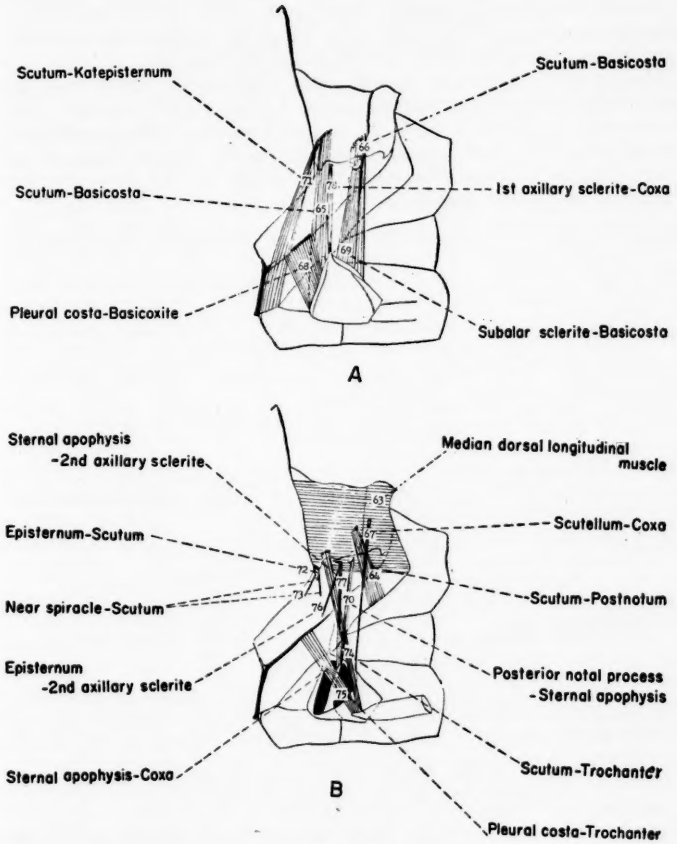


PLATE 8

Muscles of the metathorax.

says that the last muscle (78) attaches on the anterior notal process. This muscle is apparently homologous to the muscle between the first axillary sclerite and the coxal process in the mesothorax of *Siphlonurus columbianus*. Neither Knox (1935) nor Maki (1938) described the muscle from the episternum to the second axillary sclerite in *Siphlonurus columbianus*.

Sternocoxal muscles: Three muscles arising from within the coxa attach on the base of the sternal apophysis as in the proleg.

Transverse muscles (Plate 7, B): A fine transverse muscle coming from the lower portion of the pleural costa and the sternal apophysis is connected with the thicker muscle between the bases of the sternal apophyses.

Ventral longitudinal muscle (Plate 7, B): The ventral longitudinal muscle is thin and connects the posterior margin of the metathoracic sternal apophysis and the antecosta of the second sternal abdominal segment.

Maki (1938) describes a ventral longitudinal muscle connecting the meso- and metathoracic sternal apophyses. Knox (1935) describes a wide muscle attaching to the evagination of the basicoxite at the pleural-coxal articulation which extends caudad to insert to the anterior ridge of the first abdominal segment. The present writer did not see the above two muscles in *Siphlonurus columbianus*.

TABLE I. Thoracic dorso-ventral muscles in *Siphlonurus columbianus* McDunnough

	Prothorax	Mesothorax	Metathorax
Noto-subcoxal muscles			
Noto-katepisternal	1	1	1
Noto-anepisternal	1	2	2
Noto-coxal muscles			
Anterior noto-coxal	1	1	1
Posterior noto-coxal	3	3	2
Subcoxo-coxal muscles			
Katapleuro-coxal	1*	1	1
Subalar-coxal	0	1	1
Subalar-sternal muscle	0	2	1**
Basalar-sternal muscles	0(2)	2	0
Trochanteral muscles			
Noto-trochanteral	1	1	1
Katapleuro-trochanteral	1	1	1
Axillary muscles			
First axillary-coxal	0	1	1
Second axillary-sternal	0	1	1
Second axillary-subcoxal	0	1	1

* Originates from the episternum
** Dorsal point of attachment is posterior notal process

DISCUSSION ON THE THORACIC MUSCULATURE OF THE ORDER EPHEMEROPTERA

From the above description of the thoracic dorso-ventral muscles and the table showing the dorso-ventral muscles of *Siphlonurus columbianus* McDunnough some peculiarities of the musculature are noted.

First, the occurrence in this primitive species *Siphlonurus columbianus* McDunnough of the axillary sclerite which can be homologized with the third axillary sclerite in other orders of pterygote insects and of a muscle inserted on the posterior margin of the second axillary sclerite where the third axillary sclerite articulated to it precludes the acceptance of Grandi's contention (1947) on its face value that the axillary sclerites in this order are not homologous to those occurring in other orders of pterygote insects. The absence of the third axillary sclerite in many other species studied by Grandi is apparently secondary. The occurrence of the muscle here questioned is apparently correlated with the occurrence of the third axillary sclerite. This muscle, though attached to the second axillary sclerite in this species, may be regarded as the muscle of the third axillary sclerite judging from the correlation in the occurrence between the muscle and the third axillary sclerite and the point of attachment of the muscle to the second axillary sclerite. The peculiarity of the axillary sclerites in Ephemeroptera is the loss of relationship between each particular sclerite and the base of each particular vein due to strong development of the area corresponding to the median plate in other pterygote orders.

In connection with the axillary sclerites attention should be directed to the fact that the dorsal points of attachment of axillary muscles which are apparently functionally the point of insertion are subject to specific differences within certain limits. It is generally believed that the origin of the muscle tends to shift, but the above example clearly indicates that the insertion also tends to shift as Matsuda contended (1956). It would be also true of some other muscles attached to the other sclerites beneath the lateral margin of the notum although we are not as sure about their function as we are about the axillary muscles.

The second axillary muscle arising from the sternal apophysis is peculiar to this order.

Another peculiarity of the mayfly thoracic musculature is the presence of the sterno-subalar muscle. No other pterygote insect orders are known to have this muscle. Maki (1938), however, contends that the subalar sclerite in winged insects probably belongs to the tergal region based on the observation of postembryonic development of the coxo-subalar muscle in *Leucophaea surinamensis* L. (Blattidae) and *Locusta migratoria manilensis* (Acridiidae). If so, this muscle can be homologized with the posterior noto-sternal muscle in other pterygote insects. Knox's account (1935) on this muscle in the nymph, however, shows that the subalar sclerite is subcoxal in origin. The occurrence of the huge furcasterno-subalar muscle only in the mesothorax is also a striking feature of the dorso-ventral musculature in the mayfly thorax.

The anterior noto-coxal muscle is known to occur in Ephemeroptera, Odonata, and higher Lepidoptera (Maki, 1938). This muscle is apparently homologous with the noto-trochantinal muscle in other pterygote insects. The occurrence of the anterior noto-coxal muscle is said to be associated with the loss of a visible trochantin (Snodgrass, 1935, Larsén, 1948). This is true of this order.

The sterno-basalar muscle which extends between the prothoracic sternal apophysis and the mesothoracic basalar sclerite in *Siphlonurus columbianus* or area posterior to the prothoracic sternal apophysis and the mesothoracic basalar sclerite in other species of Ephemeroptera are homologous with the sterno-pleural intersegmental pair of muscles of *Locusta migratoria* (Albrecht, 1953). This muscle seems to be common in the orthopteroid insects. In Neuroptera the muscle between the anterior part of the mesothoracic anepisternum and the prothoracic spina in *Agulla adnixa* is probably homologous to this muscle.

The trochanteral muscles occur in the notum and subcoxa as in most other orders. There is no deviation as far as these muscles are concerned.

The basalar-coxal muscle is absent in *Siphlonurus columbianus* although Maki (1938) describes this muscle in *Ecdyonurus hyalinus*.

As already noted, the posterior noto-coxal muscle which attaches on the meral wall in other orders of pterygote insects attaches on the posterior basicosta. The subalar coxal muscle is present in both the meso- and metathorax.

The noto-subcoxal muscle which is usually called the anterior tergosternal muscle was found to be present in all thoracic segments in *Siphlonurus columbianus*, and it was found that this muscle retains its primitive point of insertion without shifting into the sternal region as was already pointed out by Börner (1908).

The katapleuro-coxal muscle originates from the pleural costa of Ferris, the point suggested hypothetically as the primitive point of origin of this muscle in pterygote insects by Matsuda (1956).

The occurrence of a robust transverse muscle which connects both coxae in the mesothorax seems to be, as far as known, peculiar to *Siphlonurus columbianus*. No such muscle in any order is described in Maki's monograph (1938).

The absence of the ventral longitudinal muscle between the meso- and metathoracic sternal apophyses is also characteristic to this order of insects although it was found to occur in *Ecdyonurus hyalinus* by Maki (1938).

SUMMARY

1. The external structure and the musculature of the thorax of a mayfly *Siphlonurus columbianus* were studied.

2. It was found that the subcoxal rings are clearly indicated in the pleuro-sternal region of this species. The pleural costa of Ferris (1939) is represented by a strongly sclerotized depressed costa and it extends posteriorly into the epimeral region.

3. Among the dorso-ventral muscles the presence of the sterno-subalar muscle is most characteristic of the order Ephemeroptera. The points of insertion of the posterior noto-coxal muscle and the noto-subcoxal muscle (anterior tergo-sternal muscle) and the point of origin of the katapleuro-coxal muscle fit the "Hypothetical primitive dorso-ventral musculature of a ptero-thoracic segment" postulated by Matsuda (1956).

4. The presence of three distinct axillary sclerites homologous to those in other pterygote orders and the associated musculature in this primitive species *(Siphlonurus columbianus)* preclude the acceptance of Grandi's concept "Pseudopteralia" (1947) appropriated to this region of the order Ephemeroptera on its face value.

LITERATURE CITED

Albrecht, F. 1953. The anatomy of the migratory locust, Univ. London.
Börner, C. 1908. Die Tracheenkiem der Ephemeriden, Zool. Anz. 33, SS. 806-823.
Dürken, B. 1907. Die Tracheenkiem der Ephemeriden unter Berücksichtigung der Morphologie des Insektenflügels, Zeits, wiss. Zool. 87, SS. 435-550.
Ferris, G. 1940. The myth of the thoracic sternites of insects, Microentomology 5, 3, pp. 87-90.
Grandi, M. 1947. Contributi allo studio degli "Efemeroidei" italiani VIII. Gli scleriti ascellari (Pseudopteralia) degli Efemeroidei, Loro Morfologia e Miologia Comparate, Boll. Istit. Ent. Univ. Bologna 16, pp. 85-114.
Knox, V. 1935. The body wall and the musculature of the thorax *(Hexagenia recurvata)*, in Needham et al, "The biology of mayfly," pp. 135-178.
Larsén, O. 1944. Das Meron der Insekten, Kungl. Fysiogr. Sällsk, Lund Förh. 15, 11, SS. 1-9.
Larsén, O. 1944. Die hintere Region der Insektenhüfte, Kungl. Fysiogr. Sällsk. Lund Förh. 15, 12, SS. 1-12.
Larsén, O. 1948. Die dorsoventralen Muskeln im Pterothorax der neuropteroiden Insekten, Opusc. Ent. 13, SS. 27-35.
Maki, T. 1938. Studies on the thoracic musculature of insects, Mem. Fac. Sci. and Agr. Taihoku Imp. Univ. 24, 1, pp. 1-343.
Matsuda, R. 1956. A comparative morphology of the thorax of two species of insects, Microentomology 21, 1, pp. 1-65.
Snodgrass, R. 1935. Principles of insect morphology. McGraw-Hill Book Co., Inc., New York.

MITES OF THE GENUS *BREVISTERNA* KEEGAN, 1949 (Acarina—Haemogamasidae)[1]

R. W. STRANDTMANN
Texas Technological College, Lubbock
and
DORALD M. ALLRED
Ecological Research, Dugway, Utah

Mites of the genus *Brevisterna* probably are intermediate between the Dermanyssidae and the Haemogamasidae, but the majority of their external characteristics indicate that they are Haemogamasids. Ewing indicated his belief that this was so by describing the first species of this genus as *Euhaemogamasus utahensis* (1933). When Keegan began a revision of the family Haemogamasidae, he noted that the species had a smooth epistome and a greatly abbreviated sternal plate in both the male and female. Therefore, and justly so, he created a new genus for the reception of this mite, and placed it in the family Laelaptidae, subfamily Laelaptinae, chiefly on the basis of the smooth-margined epistome. This was a logical move if only the

[1] Supported in part by research grant RG-4073 (C2) from the National Institutes of Health.

epistome were considered, as in all the Laelaptinae it is smooth-margined. But when one also considers the number of deutosternal teeth, the type of chelicerae, the sparsely ciliated tritosternum and the number of setae on the genito-ventral plate, it becomes apparent that the epistome is the only character that would place it in the Laelaptinae; everything else argues for the Haemogamasidae. Baker and Wharton (1952) placed the species in the family Dermanyssidae, for which it does show some affinity, but the well-developed peritremal plate, the numerous accessory setae on the genito-ventral plate, and the stout chelicerae indicate a close relationship to the Haemogamasids.

A restudy of the type of *Liponyssus montanus* Ewing, 1922, proved it to be a species of *Brevisterna* distinct from *utahensis*.

A species closely related to *utahensis* has been found on *Neotoma* spp. in Texas and New Mexico and is here described as new. The addition of these two species to the genus makes a modification of Keegan's original diagnosis necessary.

Genus *Brevisterna* Keegan, 1949:222

Type: *Euhaemogamasus utahensis* Ewing, 1933:4.
Synonym: *Sternolaelaps* Zumpt and Patterson, 1951:78.
Type: *Euhaemogamasus utahensis* Ewing.

In the female, the sternal plate is abbreviated in length and bears only the anterior or the median pair of usual sternal setae; accessory setae may be present. The genitoventral plate is tongue-shaped and bears accessory setae. The anal plate is oval with the usual three setae; accessory setae may be present. The dorsal plate may be entire, or there may be a small pygidial plate. The chela consists of a strong, toothed, movable digit and a long, slender, weak, bluntly tipped, generally striated immovable digit. A long, slender pilus dentilus arises from the upper third of this digit.

In the male, the holoventral plate is narrow and encompasses the anus; the usual setae and accessory setae are present. The dorsal plate is undivided and covers nearly all the dorsum. The chela is similar to the female except it bears a blunt, strongly incurved spermatodactyl which is attached to, and slightly overreaches the movable digit.

In the deutonymph, the sternal plate has four pairs of setae; there are several small platelets posterior to this shield. The anal plate is similar to the female but not as long. The dorsal plate is large, with two anterolateral plates and several pairs of small platelets posterior. The chela is similar to the female.

In the protonymph and larva the plates are not distinct. The chelae are simple without teeth on either digit.

In all stages the peritreme is short, barely reaching beyond coxa III. The peritremal plate is well developed in the male and female and extends to the middle of coxa I. In the deutonymph the plate extends only to coxa II; in the protonymph barely past the peritreme.

All coxae and legs are without modified setae except in the male where a blunt spur and a heavy, elevated seta occur on femur II.

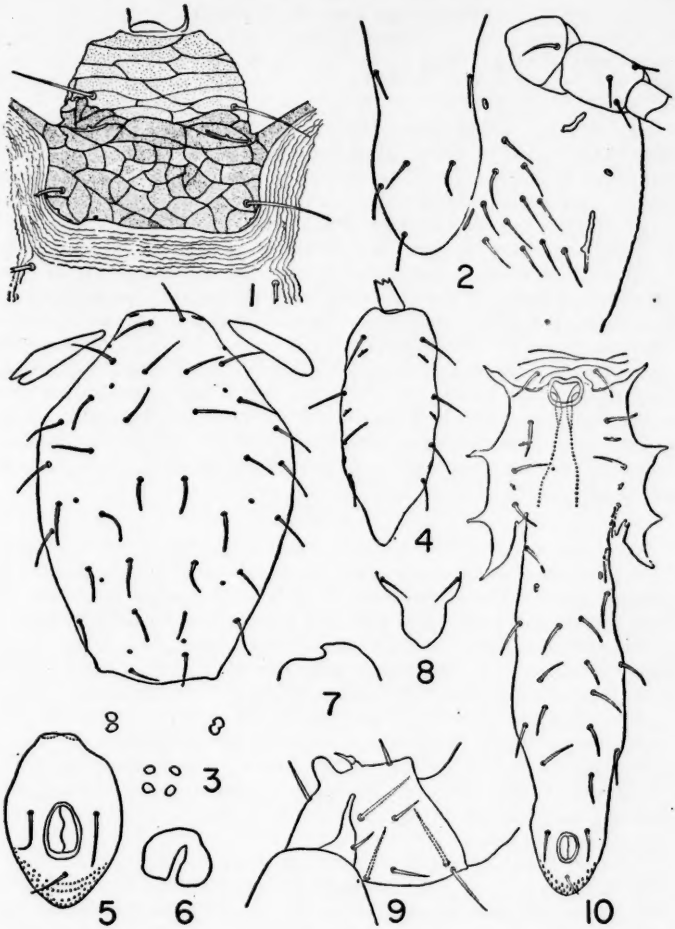


PLATE I
Brevisterna utahensis

FIG. 1. Sternal plate of female.
FIG. 2. Genitoventral and metapodal plates of female.
FIG. 3. Dorsal plates and platelets of deutonymph.
FIG. 4. Ventral plate of deutonymph.
FIG. 5. Anal plate of deutonymph.
FIG. 6. Fusion of posterior dorsal platelets of deutonymph.
FIG. 7. Variation in shape of anterior tip of anal plate of deutonymph.
FIG. 8. Variation in shape of posterior tip of ventral plate of deutonymph.
FIG. 9. Right femur II of male (ventro-lateral view).
FIG. 10. Holoventral plate of male.

Brevisterna utahensis (Ewing)

(Plates I, II, Figs. 1-18)

Euhaemogamasus utahensis Ewing 1933:4. Plate I, fig. 4.
Brevisterna utahensis (Ewing), Keegan 1949:244. Plates I and II, figs. 1-12.
Sternolaelaps utahensis (Ewing), Zumpt and Patterson, 1951:78.

In Keegan's (1949) redescription of the female and original descriptions of the male and nymph, there are certain characteristics which differ from those found in other mites of this species collected in Utah. Examination of several hundred specimens collected from wood rat nests from one specific locality in Utah has shown that considerable variation exists in this species. Examination of the types by the senior author has shown that Keegan's illustrations of the chelae of the male and female are in error. Specimens collected by the junior author from Carbon, Tooele, Washington, Grand and Wayne counties in Utah are similar to the descriptions of the types except for several characteristics listed in Table I. Redescriptions of the female, male and deutonymph ("nymph" of Keegan), and original descriptions of the protonymph, larva and egg which follow include some of the variations found in the types and other specimens examined. Some of these mites have variations from the types which are sufficiently constant to indicate distinct geographic races, but for the present, at least, these are not being subdivided.

FEMALE

Idiosoma: Length, 795 to 1,030 microns; width, 561 to 734 microns.

Gnathosoma: One and one-fourth times as wide as the length from the anterior edge of the idiosoma to the base of the palpal trochanter. All hypostomal setae nude; basal pair and anterior pair equal in length, approximately 50 microns; middle internal pair longest, 62 microns; middle external pair shortest, 38 microns. All palpal setae nude. Length of palps from base of trochanter, 144 microns. Chelicerae strongly chelate. Digitus mobilis with two subterminal and one terminal teeth; surrounded by a transparent, rounded bursa with a distinct notch medially on the internal edge. Digitus fixus fingerlike, slightly sinuous with a blunt tip; with a subterminal setalike pilus dentilus about 10 microns long; with transverse striations from its base to the insertion of the pilus dentilus; with a transparent, elongate bursa.

Venter: Basal segment of tritosternum about one and one-half times as long as wide; fork of lacinae beginning almost at basal segment; lacinae with large barbs from base almost to tip; lacinae about 168 microns long, not reaching to base of palpal trochanter, but to a point more than midway between the basal and middle hypostomal setae. Presternal area reticulate, with minute pits. Sternal plate approximately twice as wide as long, reticulate, with minute pits; with only middle pair of sternal setae and two pairs of slitlike pores; first pair of pores near anterior edge of plate, directly posterior to first pair usual sternal setae which are in the presternal area; second pair pores on posterolateral edge of plate; third pair usual sternal setae in unsclerotized portion of venter behind sternal plate; all sternal setae nude, first and second pairs about equal in length, 52 microns; third

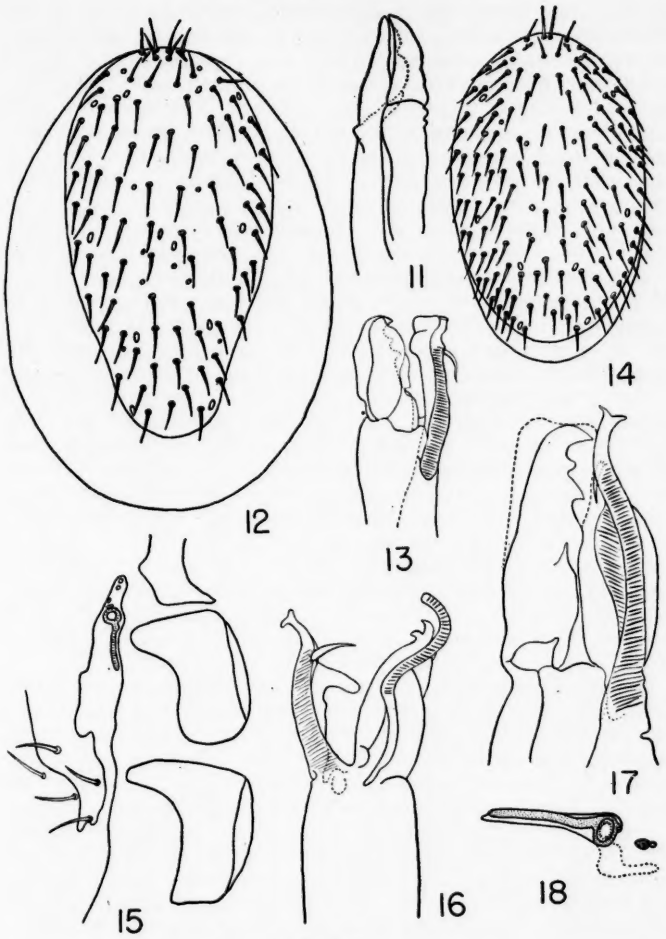


PLATE II

Brevisterna utahensis

FIG. 11. Left chela of protonymph (ventral view).
FIG. 12. Dorsal plate of female.
FIG. 13. Left chela of female (ventral view).
FIG. 14. Dorsal plate of male.
FIG. 15. Left peritreme and peritremal plate attached to dorsal plate of male.
FIG. 16. Right chela of male (ventral view).
FIG. 17. Left chela of deutonymph (ventral view).
FIG. 18. Peritreme of deutonymph.

pair 74 microns. Genitoventral plate rounded posteriorly, widest at level between coxae III and IV; with minute pits, conspicuously reticulate anteriorly; with usual pair of genitoventral setae opposite posterior edge of coxae IV, and three to eleven accessory setae posterior to usual setae. Unsclerotized portion of venter with approximately 62 pairs setae, 40 to 48 microns long; posterior setae barbed and thicker than anterior setae. With a pair of elongate accessory plates near posterolateral margin of genitoventral plate (an additional plate occasionally is present); a pair of prominent pores in plates slightly lateroposterior to usual genitoventral setae. Two pairs metapodal plates; anterior pair elongate and slightly curved, about five times as long as wide, situated immediately posterior to coxae IV; posterior pair metapodal plates elongate, straight, about eight times as long as wide, situated near lateral margin of venter opposite posterior end of genitoventral plate. Anal plate long oval, reticulate with minute pits; with two anterior prominences (missing in some specimens); anus situated slightly posterior to middle of plate; paired adanal setae approximately 43 microns long, situated opposite anterior half of anus; posterior seta 36 microns long; lateral edges of cribum extending to a point anterior of the posterior seta but not to the base of the anus. Distance between the anal and genitoventral plates less than the length of the anal plate. Peritreme short, not extending to anterior edge of coxa III. Peritremalia reaching to middle of coxa I, with two dorsal lobes, one at level of coxae III and IV, and the other at level of coxae I and II.

Legs: Legs I thinner than others which are of about equal thickness; legs I, 714 microns long exclusive of caruncle; legs II, 520 microns; legs III, 601 microns; legs IV, 744 microns. Lengths of tarsi and length: width ratios are: I-204 microns, 6.1:1; II-147 microns, 3.4:1; III-171 microns, 4.5:1; IV-223 microns, 5.9:1. All setae on the legs are nude.

Dorsum: Dorsal plate reticulate, most conspicuously at anterolateral angles; entire plate covered with minute pits; broad anteriorly, covering about one-half of the dorsum and tapering to blunt point posteriorly; approximately 892 microns long, ending at level of posterior end of anus; widest at level of coxae II, 480 microns; posterolateral sides slightly concave; with approximately 45 pairs nude setae 30 to 91 microns apart; those on anterior part of plate largest, 38 to 52 microns long; setae on posterior part of plate 33 to 43 microns long; most anterior middle pair of setae largest, thicker than others and 57 microns long; with 7 pairs large and 5 pairs small pores. Unsclerotized portion of dorsum with approximately 100 pairs setae about equal in size to those of anterior part of plate; posterior setae barbed.

MALE

Idiosoma: Length, 700 to 798 microns; width, 364 to 510 microns.

Gnathosoma: One and one-third times as wide as the length from the anterior edge of the idiosoma to the base of the palpal trochanter. All hypostomal setae nude; basal pair 38 microns long, internal middle pair 52 microns, external middle pair 33 microns, anterior pair 43 microns. Length of palps from base of trochanter, 144 microns. All palpal setae nude. Cheli-

cerae strongly chelate, both segments of about equal length. Digitus mobilis appearing to consist of two parts, a broad basal part with one terminal and one subterminal teeth, and a fingerlike, sinuous part which extends slightly past the toothed part. Digitus fixus slightly sinuous, terminating in a blunt, concave tip; with a setalike pilus dentilus situated about one-third the distance from the tip; with a transparent bursa which has a flattened, rounded lobe projecting at a right angle to the segment, but sometimes parallel, appearing to be pointed when seen from the side.

Venter: Base of the tritosternum about five-sixths as wide as long; fork of lacinae beginning almost at basal segment; lacinae barely reaching past basal hypostomal setae, with large barbs. Presternal area reticulate. Holoventral plate widest between coxae, enclosing anus; first pair usual sternal setae 36 microns long, situated in reticulate area anterior of plate; second and third pairs usual sternal setae in normal position on the plate, equal in size to the first pair; metasternal and usual genitoventral setae slightly smaller than usual sternal setae; with 11 to 30 accessory setae about equal

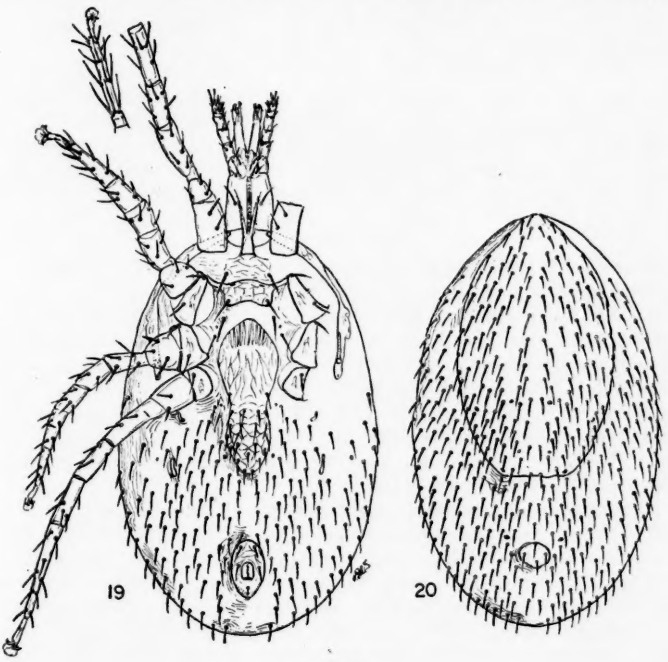


PLATE III
Brevisterna morlani n. sp., female

FIG. 19. Ventral view.
FIG. 20. Dorsal view.

in size to usual genitoventral setae; paired adanal setae situated opposite anterior half or anterior edge of anus, about equal in size to accessory setae; postanal seta slightly smaller than adanal setae; lateral edges of cribum extending to a point opposite posterior edge of anus. Genital opening projecting anteriorly into presternal area. Plate with three pairs slitlike pores; first pair situated near anterior edge of plate directly behind first sternal setae; second pair about midway between second and third sternal setae; third pair about midway between third sternal setae and metasternal setae. Unsclerotized portion of venter with approximately 50 pairs setae; anterior setae nude, equal in size to accessory setae of holoventral plate; posterior setae barbed, slightly thicker. Two pairs of metapodal plates, similar in size, shape and location to those of female. Peritreme short, as in female; peritremal plate attached to dorsal plate at level of coxa II.

Legs: Legs II thicker than others which are of about equal thickness; leg I, 642 microns long exclusive of caruncle; legs II and III, 418 microns; leg IV, 683 microns. The comparative length ratios of the tarsi when compared to tarsus II which is the shortest are I-1.7; III-1.25; IV-1.9. Femur II with a blunt, knoblike spur and a short, modified, elevated seta which is bulbous at its base.

Dorsum: Dorsal plate covering all of dorsum except posterior tip; reticulate, most conspicuously on anterior edge and shoulders; with minute pits which are not as conspicuous as on the female; with approximately 65 pairs nude setae, 28 to 50 microns long and 18 to 75 microns apart; anterior middle pair setae largest on plate; setae on anterior part of plate larger than those posteriorly; with 5 pairs large and 5 pairs small pores.

DEUTONYMPH

Idiosoma: Length, 450 to 846 microns; width, 408 to 571 microns.

Gnathosoma: Four-fifths as wide as the length from idiosoma to base of palpal trochanter. All hypostomal setae nude; basal and anterior pairs 43 microns long, external middle pair 40 microns, internal middle pair 38 microns. Length of palps from base of trochanter, 151 microns. All palpal setae nude. Chelicerae strongly chelate; digitus fixus slightly longer than digitus mobilis. Digitus mobilis with one terminal and two subterminal teeth; with a bursa. Digitus fixus fingerlike, slightly sinuous, with blunt tip; with setalike pilus dentilus near tip; striated from base of segment to pilus dentilus; with slender bursa.

Venter: Base of tritosternum three-fourths as wide as long; fork of lacinae beginning almost at basal segment; lacinate almost reaching middle hypostomal setae, with large barbs from tip almost to base. Ventral plate reticulate, twice as long as wide, tapering to blunt point at level of coxae IV; with four pairs setae and three pairs of pores; first pair setae indented near anterior margin; other three pairs of setae on lateral margins; first three pairs setae about equal size, fourth setae slightly smaller. Anal plate oval, reticulate, with two anterior prominences (lacking in some specimens) as in female; adanal setae opposite anterior edge anus, equal in size to setae on unsclerotized portion of venter; postanal seta slightly smaller

than adanal setae; sides of cribum extending slightly anterior to a point opposite the posterior edge of anus. Unsclerotized portion of venter with approximately 27 pairs setae; most posterior setae largest, barbed. Two pairs of metapodal plates; anterior pair small, about 7 microns long;

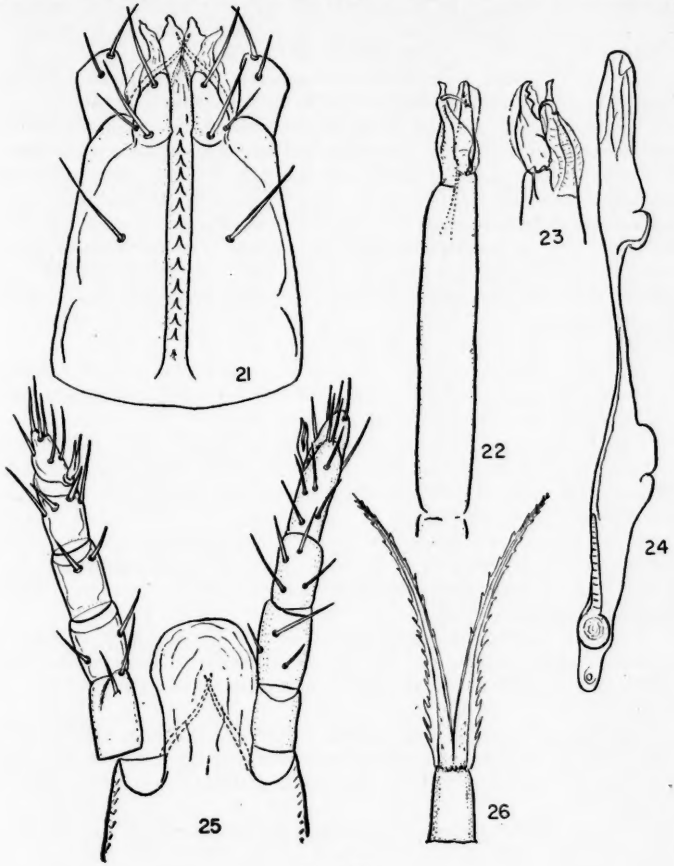


PLATE IV

Brevisterna morlani n. sp., female

FIG. 21. Ventral view of gnathosoma.
FIG. 22. Ventral view of chela.
FIG. 23. Side view of chela.
FIG. 24. Stigma, peritreme, and peritremal plate.
FIG. 25. Dorsal view of gnathosoma, showing tectum, salivary stylets, and palps with the left palp in ventral view.
FIG. 26. Tritosternum.

posterior pair larger, oval, about three times as long as wide. Three pairs of small accessory platelets and a pair of pores directly behind the ventral plate. Peritreme short, as in male and female.

Legs: Legs II slightly thicker than others. Legs I, 663 microns long exclusive of caruncle; legs II and III, 479 microns; legs IV, 642 microns. The comparative length ratios of the tarsi when compared to tarsus II which is the shortest are I-1.3; III-1.1; IV-1.4.

Dorsum: Dorsum with six to eleven plates. Largest plate reticulate, situated on anterior half of dorsum, ending at a point just posterior to coxae IV; truncate posteriorly; with 17 pairs nude setae; those on anterior part of plate largest; with one pair of slitlike and five pairs small circular pores. A pair of oblong plates at antero-lateral angles of main plate; reticulate, without setae. Two pairs of small circular plates at posterior corners of main plate; sometimes fused to form two or three plates. Four small circular plates situated postero-medially from the two pairs small plates; sometimes fused to form one, two or three plates. Unsclerotized portion of dorsum with approximately 85 pairs setae of about equal size, those posteriorly are barbed.

PROTONYMPH

Idiosoma: Length, 489 to 520 microns; width, 336 to 387 microns; soft-bodied, no plates visible; chitin of deutonymph forming internally confuses presence and arrangement of most setae.

Gnathosoma: Six-sevenths as wide as the length from idiosoma to base of palpal trochanter. All hypostomal setae nude; basal pair 14 microns long; middle pair 12 microns; other middle pair apparently absent; anterior pair 16 microns. Length of palps from base of trochanter, 136 microns; with few nude setae. Chelicerae simple, chelate; both segments of about equal length; without teeth, although digitus mobilis appears to have a small hump somewhat resembling a tooth. Bursa apparently absent. Deutosternum with 15 teeth.

Venter: Tritosternum reduced. Lacinae three times as long as the basal segment, barely reaching past the base of deutosternum; without barbs. Few small setae ventrally. Peritreme short, approximately 21 microns; no peritremalia.

Legs: Legs II thicker than others; all with six segments and few nude setae; with caruncles and a pair of minute claws; leg I, 459 microns long exclusive of caruncle; leg II, 346 microns; leg III, 316 microns; leg IV, 408 microns.

Dorsum: With few small, nude setae; several moderately large setae on posterior end of idiosoma.

LARVA

About same size as the protonymph, soft-bodied, evidently without plates and with few setae as in protonymph. With three pairs of legs with few setae. Very inactive and of short duration.

EGG

Oval, white, shiny and transparent; 0.62 mm by 0.35 mm.

ADDITIONAL HOST AND DISTRIBUTION RECORDS

Utah: Tooele County: *Neotoma lepida,* Camelback Mountain; nests of *N. lepida,* White Rock, Cedar Mountains; *Peromyscus crinitus;* Granite Mountain. Wayne County: *Peromyscus crinitus,* Dead Horse Point. Washington County: *Peromyscus eremicus,* Terry Ranch, Beaver Dam Wash. Carbon County: *Peromyscus maniculatus,* Price. Grand County: *Neotoma lepida,* Moab.

TABLE I. Variations of descriptions of *Brevisterna utahensis*

	Ewing and Keegan	Strandtmann and Allred
Female		
Length of setae on dorsal plate	35	33-52
Distance between setae on dorsal plate	30-60	32-91
Pores on dorsal plate	5 pr.	12 pr.
Dorsal body setae	smooth	smooth and barbed
Genitoventral accessory setae	8-11	3-8
Metopodal shields	2 pr.	3 pr.
Length-width ratios of tarsi		
I	8.5:1	6.1:1
II	4.5:1	3.4:1
III	6.0:1	4.5:1
IV	9.0:1	5.9:1
Anal plate projections	present	present or absent
Number of dorsal plate setae	55 prs. (?)	45 prs.
Cribum extends	past anus	not to anus
Number of ventral setae	49 prs. (?)	62 prs.
Tritosternum extends	past middle gnathosomal setae	past basal gnathosomal setae
Male		
Number of dorsal plate setae	51 prs. (?)	65 prs.
Tritosternum extends	past middle gnathosomal setae	to basal gnathosomal setae
Number of ventral setae	49 prs.	50 prs.
Number of dorsal pores	3 prs. (?)	10 prs.
Number of accessory setae on holoventral plate	30 (?)	11 to 24
Metapodal plates	1 pr. (?)	2 prs.
Distance between dorsal setae	30-60 microns	18-75 microns
Length of dorsal setae	35 microns	28-50 microns
Deutonymph		
Dorsal pores	lacking as adults	6 prs. longer than adults
Tritosternum		

Brevisterna morlani n. sp. (Plates III-VI, Figs. 19-31)

The body setation is dense, moderately short, and uniform. No setae are markedly longer than others and none are modified, except on leg II of the male. The female averages one millimeter long; the male about 0.7 millimeter.

FEMALE (Figs. 19-26)

Average length of idiosoma, 950 microns, varying from 870 to 1,100; average width, 590 microns, varying from 500 to 650.

Gnathosoma (Figs. 21, 25): Deutosternal teeth vary from 12 to 15 and are in single file. Gnathosomal and hypostomal setae rather long, slender, and smooth; corniculi irregular and hyaline. All palpal setae slender and smooth. Salivary stylets slender and moderately long. Chelicerae moderatey slender but not attenuated; well developed. Digitus mobilis well sclerotized and fairly heavy with two subapical teeth below the slightly hooked apex. Digitus fixus about one fourth longer than mobilis and seems to be hinged at base. It is nearly hyaline, transversely striated, medially winged, with a blunt apical attenuation, and bears a prominent seta near the apex. No sub-cheliceral setae or setalike processes.

Venter (Fig. 19): Sternal plate severely reduced, bearing only the middle pair of sternal setae, but strongly reticulated. Sternal pores I directly on the anterior margin, sternal pores II directly on the posterior corners. Anterolateral corners extend well up between coxae I and II. Presternal area lightly sclerotized and reticulated. Length of sternal setae, 80 to 85 microns; length of sternal plate medially, 60 microns; width at posterior corners, 130 microns. Genitoventral plate extends from the middle of coxae II nearly to the middle of the idiosoma; narrowly tongue-shaped and constricted between coxae IV, where genital setae are attached. Genital setae, 40 to 43 microns. Anterior region of plate prominently marked with longitudinal lines; posteriorly the reticulations are more transverse and rectangular. There are an average of 20 setae evenly dispersed on the plate below the genital setae. The number varies from 15 to 23 and they average 60 microns long. Anal plate broadly oval, measuring 165 microns long by 110 microns wide, being nearly as wide as the genitoventral and about its length from it. It has three paranal setae and nearly always two but sometimes none, or only one, accessory setae near the anterior margin. Anal pore lies below the middle; paired anal setae near front margin of anal pore. A narrow cribrum subtends hind margin of plate. Metapodal plates parallel to long axis of body; 67 microns long by 10 wide; straight and narrow. A slightly smaller, curved platelet lies just below coxa IV, a small circular spot lies near the genitoventral plate and another just outside of the metapodal plate. Venter, below the legs, as thickly beset with setae as is the dorsum. Ventral setae average about 60 microns long. All coxal setae smooth and slender and about of a length with the other setae. Coxae are devoid of spurs or spines, but the anterior or apical margin of coxa I, and anterior-dorsal quadrant of apices of coxae II and III are dentate. The stigma is on a line between coxae III and IV and about midway between the coxae and the margin of the body. Peritremalia below the stigma about twice as long as diameter of the stigma, bluntly pointed and bearing a pore near the tip. Peritreme narrow and short, not reaching beyond front edge of coxa III; peritremal plate well developed and long, reaching almost to coxa I. The plate is narrow and occasionally broken opposite coxa II. Beyond and before this region, the plate is broad and lightly marked with lines. No endopodal plate. Endopodal seta present with third sternal pore just anterior to it, and third sternal seta just anterior to the pore. Base of tritosternum 50 microns long by 33 microns wide. Lacinae branch near

base, have a hyaline, serrated outer margin, are themselves lightly serrated, are about 165 microns long, and reaching just beyond the gnathosomal setae.

Legs: No unusual characteristics. All setae smooth, slender and moderately long. Leg II shorter and slightly heavier than others. Legs I and IV longest and equal. (Legs were not measured because none were properly extended.) Tarsal lengths, and length:width ratios are: I-245 microns, 8.1:1; II-175, 4.5:1; III-180, 5.8:1; IV-286, 8.6:1.

Dorsum: Entire dorsal side thickly beset with smooth, slender, moderately long setae that are similar in size over the entire dorsum. In mounted specimens, with the setae lying flat, the tips of the setae reach

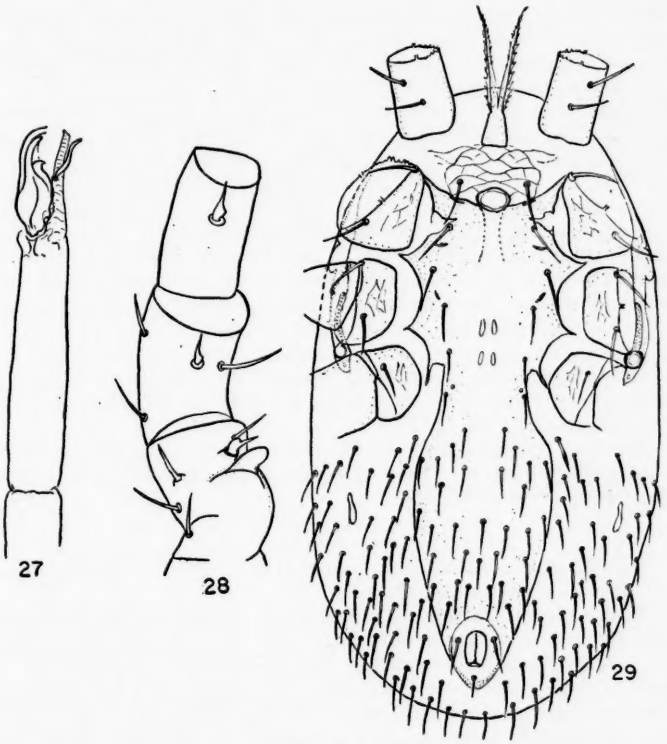


PLATE V
Brevisterna morlani n. sp., male
FIG. 27. Side view of chelicera.
FIG. 28. Ventral view of femur, genu, and tibia of leg II.
FIG. 29. Ventral view.

beyond the bases of the following setae by about a quarter their length. Setae on the dorsal plate average 57 microns; the others, including those on the pygidial plate are about 50 microns. Posterior margin of large dorsal plate irregularly eroded, lateral and front margins smooth and intact. Small pygidial plate more than its diameter from the anterior plate. It may be variously eroded but general shape is circular. It averages four setae, with a range of two to six.

MALE (Figs. 27-29)

Length, 770 microns; width, 462 microns. Leg II with several modified setae but otherwise chaetotaxy of male same as of female.

Gnathosoma: Similar to female except chelae are slightly modified. Digitus fixus narrow, striated, and bearing a long slender seta medially. Digitus mobilis rather massive basally but apex slender and edentate. Spermatodactyl a slightly curved process, a little longer than digitus mobilis and apparently open at tip. Inner mid-region of the digitus mobilus bears a short, curved tooth (Fig. 27).

Venter (Fig. 29): Ventral plates fused into an unbroken holoventral plate. First sternal setae and genital pore lie anterior to front margin of this plate. Presternal area lightly sclerotized and reticulated up to base of the tritosternum. Entire plate reticulated. With 4 pairs of pores; pores I and II transverse and opposite coxae II, pore III about 45° from horizontal and opposite coxae III, pore IV circular and opposite coxae IV. No accessory setae in the sternal region. Number of setae between genital and anal setae varies from 35 to 50 and averages around 42. Sternal setae, 50 to 53 microns, genital setae 33 microns; accessory setae about 45 microns; ventral setae not on the plate, about 40 to 43 microns long.

Legs: Femur of leg II with a thumblike, ventral apophysis, and the femur, genu, tibia and tarsus of leg II each with a modified, ventral seta which is shorter than the other setae and is basally inflated (Fig. 28). Chaetotaxy otherwise as the female.

Dorsum: The dorsal plate is entire and covers all of the dorsum except a narrow band posteriorly. Setae on the dorsal plate about 35 to 40 microns long; others about 40 microns.

DEUTONYMPH (Figs. 30-31)

Average length, 625 microns, varying from 570 to 700; average width, 400 microns, varying from 345 to 500.

Venter (Fig. 31): Sternal plate uniformly sclerotized and reticulated from the base of tritosternum to the roundly pointed tips between coxae IV. It bears 4 pairs of setae and 3 pairs of pores. Four to seven pairs of small platelets posterior to the sternal plate. A pair of small metapodal plates are present. Anal plate may have one or two pairs of accessory setae but generally these are lacking. Peritreme is only half as long as in female; peritremal plate poorly developed. Sternal setae averaging 50 microns; other ventral setae average 42 microns. Tritosternum a little shorter than in female.

Dorsum (Fig. 30): The dorsal plate is broadly elliptic and covers about

one-half to two-thirds of the dorsal surface. It measures 410 microns long by 290 wide. Two or three pairs of small platelets may be found posterior to the plate and a cluster of three or four platelets are present in the pygidial region. Dorsal setae average 43 microns long.

PROTONYMPH

Several protonymphs were found and recorded but none were available for critical study.

LARVA and EGG are unknown.

TYPE HOST

Neotoma albigula algibula Hartley, the white-throated wood rat.

TYPE LOCALITY

Steel Ranch, Santa Fe, New Mexico. 26 October, 1951. H. B. Morlan, collector.

TYPES

Holotype, a female bearing the above data. Deposited in the Acarina collection of the U. S. National Museum, Washington, D. C. Paratypes, 32 males, 30 females, and 8 deutonymphs collected from nest of *Neotoma albigula albigula,* Santa Fe, New Mexico, 29 November, 1951, by H. B. Morlan, collector. Paratypes have been sent to the United States National Museum, Washington, D. C.; the British Museum (Natural History),

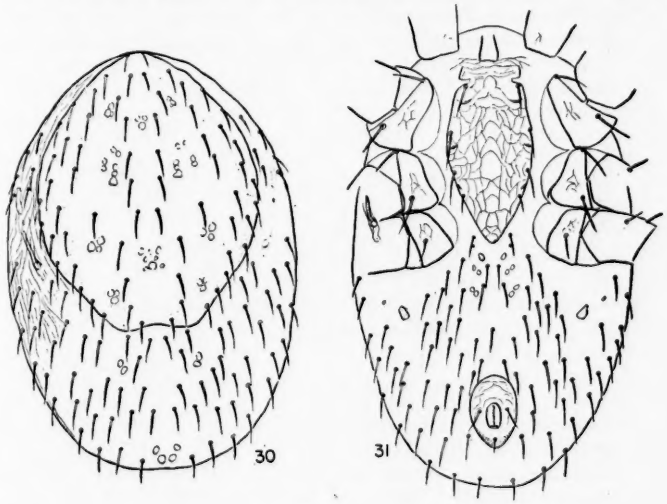


PLATE VI

Brevisterna morlani n. sp., deutonymph

FIG. 30. Dorsal view.

FIG. 31. Ventral view.

London; Dr. Jean Cooreman, Bruxelles; Dr. R. B. Eads, Texas State Health Laboratory; Dr. Deane P. Furman, University of California; Harvey B. Morlan, Savannah; Dr. Harry D. Pratt, Atlanta; and Dr. F. Zumpt, Johannesburg.

DISCUSSION

Additional host and locality records that we have are: *Neotoma* sp. Colorado, Otero Co., May 16, 1950, R. B. Finley, collector; *Neotoma micropus,* Lubbock Co., Texas, several collections in 1954 and 1955.

Mr. Harvey B. Morlan has very kindly supplied us with the collection data obtained at the Santa Fe County, New Mexico plague survey. His letter and records are quoted below.

"These collections were made incidental to a plague ecology study by the Communicable Disease Center, Public Health Service, U. S. Department of Health, Education, and Welfare. A general description of the study has been prepared by Holdenried and Morlan (unpublished manuscript). Information on mammal nest studies has been reported with special reference to fleas by Morlan (1955).

"Detailed collection data are as follows (In each case the collection date is followed by the number of animals examined or re-examined, the number infested, the number of mites collected):

"St. Michael's College:
Cynomys gunnesoni zuniensis Hollister;
July, 1952; 11; 1; 1F.

"Santa Fe County Survey:
Neotoma albigula albigula Hartley;
September, 1951; 69; 8; 1N, 2M, 8F.
March, 1952; 10; 2; 1M, 1F.

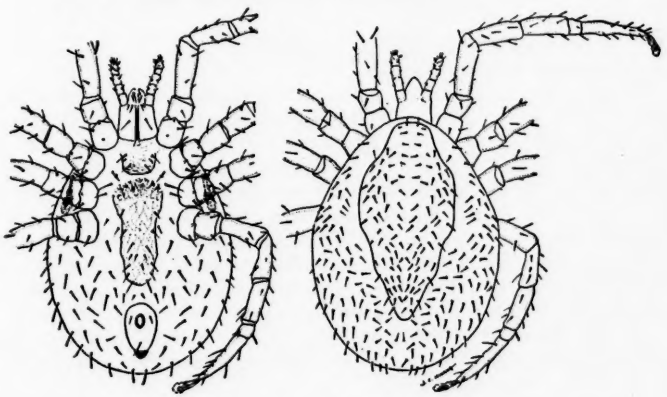
"Teal Ranch:
N. a. albigula;
May, 1953; 13; 1; 1F.
July, 1953; 18; 2; 4F.

"Steel Ranch:
N. a. albigula;
October, 1951; 10; 1; 1F (Holotype).
May, 1952; 1; 1; 1F.

"Santa Fe Municipal Airport:
Dipodomys ordii medius Setzer;
October, 1951; 162; 1; 1F.
N. a. albigula;
October, 1951; 24; 6; 1M, 7F.
November, 1951; 11; 1; 2F.
June, 1952; 58; 4; 4F.
July, 1952; 66; 8; 4N, 1M, 18F.
August, 1952; 59; 3; 3F.
September, 1952; 73; 5; 5F.
October, 1952; 82; 2; 1N, 1F.
June, 1953; 15; 1; 1F.

July, 1953; 15; 1; 1F.
Neotoma micropus canescens Allen:
December, 1951; 9; 1; 2NI.
May, 1952; 39; 2; 1NII, 1F.
June, 1952; 28; 1; 1F.
July, 1952; 43; 2; 2F.
August, 1952; 38; 1; 1F.
September, 1952; 33; 2; 2F.
April, 1953; 15; 1; 1F.
June, 1953; 17; 2; 5F.
July, 1953; 15; 4; 2M, 4F.
August, 1953; 15; 1; 1F.
Peromyscus leucopus tornillo Mearns;
October, 1952; 10; 1; 1F.
Peromyscus maniculatus rufinus (Merriam)
June, 1953; 11; 1F.
Peromyscus truei truei (Shufeldt);
April, 1952; 30; 1; 2F.
Sylvilagus audubonii warreni Nelson;
October, 1952; 9; 1; 1F.

"Records of *Brevisterna morlani* from *N. a. albigula* nests are as follows:
No. 2; October 11, 1951; 12N, 12M, 7F.
No. 3; October 11, 1951; 5N, 5M, 1F.
No. 4; October 26, 1951; 4N, 2M, 3F.
No. 5; November 29, 1951; 74N. 77M, 64F.



32 33

PLATE VII
Brevisterna montanus, female

FIG. 32. Ventral view.
FIG. 33. Dorsal view.

No. 6; November 29, 1951; 18N, 72M, 42F. (This series includes the paratypes.)
No. 7; December 13, 1951; 18N, 13M, 7F.
No. 9; December 13, 1951; 1N, 4M.
No. 10; January 17, 1952; 26N, 51M, 113F.
No. 11; January 17, 1952; 1N, 19M, 11F.
No. 12; January 17, 1952; 2N, 2M.
No. 13; February 28, 1952; 19M, 34F.
No. 14; March 27, 1952; 11 (sex and stage not recorded).
No. 15; May 15, 1952; 35N, 40M, 16F.
No. 16; June 24, 1952; 60N, 25F.
No. 17; July 29, 1952; 6N, 20M, 14F.
No. 18; August 12, 1952; 38N, 51M, 21F.
No. 19; September 9, 1952; 13N, 14M, 5F.
No. 5-C; October 14, 1952; 1N, 1M, 2F.
No. 25-C; November 18, 1952; 4NI, 13NII, 44M, 29F.
No. 48-B; December 9, 1952; 1F.
No. 37-A; January 13, 1953; 4N, 7M, 22F.
No. 50-A; February 2, 1953; 1N, 4M, 3F.
No. 75-A; April 28, 1953; 6NI, 13M, 14F.
No. 25-C; August 18, 1953; 4M, 4F.
N. micropus canescens (Nests);
No. 1; February 29, 1952; 1N, 1M, 2F.
No. 3; April 23, 1952; 2N, 3M, 9F.
P. t. truei (Nests);
No. 1; March 27, 1952; 7 (sex and stage not recorded).

"Bernilillo County:
N. a. albigula (unnumbered); (Nests);
February 9, 1953; 7M, 7F.

"Rodent nests with collection dates from October, 1951, through September, 1952, were taken at the Dave Steel Ranch which is in parts of Sections 8 and 9, T 17 N, R 9 E; about 4 miles northwest of Santa Fe at an elevation of 6907 feet. Except for two *N. a. albigula* nests (one taken February 9, 1953, in Bernilillo County and one taken July 13, 1953, from Teal Ranch), all nests with collection dates from October, 1952, through August, 1953, were from the John T. Mastin ranch which adjoins the Albuquerque Highway about 6 miles southwest of Santa Fe city limits at an elevation of 6323 feet. The Bernilillo County collection was from Montecello Canyon in the Sandia Mountains at about 7500 feet.

"Many specimens of this mite were used for bacteriological examination. Others were sent to Dr. Harry Pratt and Frank Prince at the time the Santa Fe station was closed."

The New Mexico Survey included many species of small mammals and many nests other than *Neotoma* nests. It is, therefore, apparent that wood rats *(Neotoma* spp.) are the preferred hosts.

The role of *Brevisterna morlani* in the epidemiology of rodent diseases, or rodent borne diseases has not been sufficiently examined.

The mite is named for Mr. Harvey B. Morlan, an indefatigable worker and excellent scientist.

Brevisterna montanus (Ewing) New Combination
(Plates VII-VIII, Figs. 32-37)

Liponyssus montanus Ewing, 1922. Page 21, female.

In the acarina collection of the U. S. National Museum the type slide has been marked *"Brevisterna"* by Dr. E. W. Baker, but it has never been so recorded in print.

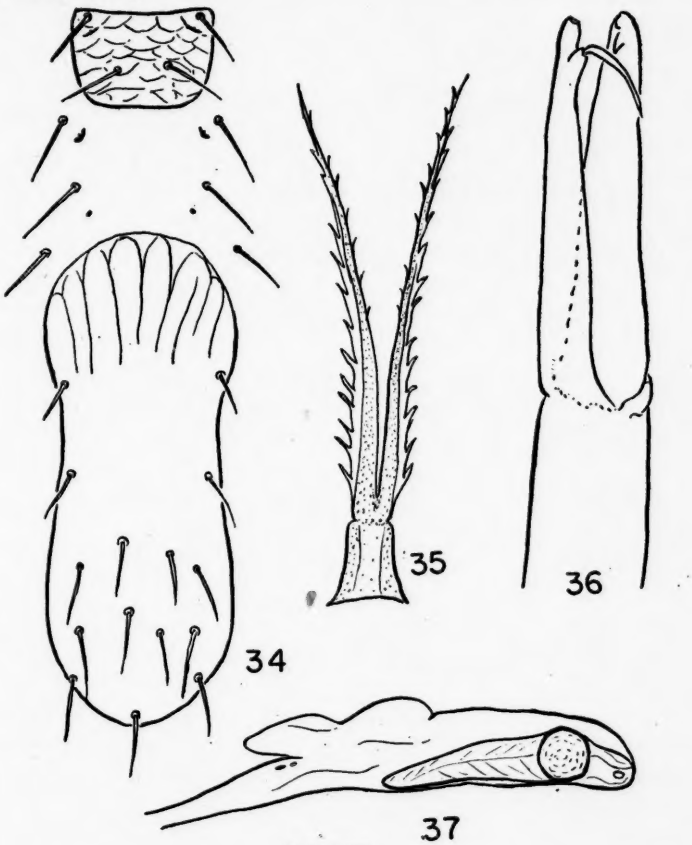


PLATE VIII
Brevisterna montanus, female

FIG. 34. Sternal and genitoventral plates, with associated pores and setae.
FIG. 35. Tritosternum.
FIG. 36. Chela, dorsolateral view.
FIG. 37. Stigma, peritreme, and part of peritremal plate.

Female: A long-legged mite, with a body length of 1 mm. In the original description, Ewing said it was "large and similar to females of *Haemogamasus*." The sternal plate is greatly reduced, bearing only the anterior pair of sternal setae and pores. Of the three specimens on the type slide, two have one pair of accessory setate (at about the middle of the plate) and one has two pairs of accessory setae. The presternal area is sclerotized.

The genitoventral plate is tongue-shaped and bears about 14 setae. The peritreme and peritremal plate are characteristic of the genus. The anal plate has only three setae. The dorsal plate is undivided and tapers to a blunt point posteriorly. In an unengorged specimen it would probably cover most of the body.

The male is unknown.

The type locality is Florence, Montana, U. S. A.

The type host is given as *"S. h. richardsoni."* This is, no doubt, *Sciurus hudsonicus richardsoni*.

We are indebted to Dr. Joe C. Hwang of Maryland University for the drawings showing the dorsal and ventral view.

THE KEY TO THE SPECIES

1. Female sternal plate bearing only the middle pair of usual sternal setae; no accessory setae 2
   Female sternal plate bearing only the first pair of usual sternal setae plus, generally, two accessory setae. Males and immature forms unknown ..... *montanus*
2. No barbed setae in any stage. Female: with a pygidial plate, ventral plate with 15 to 23 accessory setae, anal plate nearly always with 1 or 2 accessory setae. Male: holoventral plate with 35 to 50 accessory setae between the genital and paranal setae ..... *morlani* n. sp.
   Some of the posterior setae slightly barbed. Female: no pygidial plate, dorsal plate covering nearly all of the dorsum, ventral plate with 3 to 11 accessory setae, anal plate rarely with accessory setae but sometimes with projecting corners. Male: holoventral plate with 11 to 30 accessory setae ..... *utahensis*

LITERATURE CITED

Baker, E. W., and Wharton, G. W. 1951. An introdutcion to Acarology. New York: The Macmillan Co. 465 pp.

Ewing, H. E. 1922. The Dermanyssid Mites of North America. Proc. U. S. Nat. Mus. 62, Art. 13: 1-26.

Ewing, H. E. 1933. New genera and species of parasitic mites of the superfamily Parasitoidea. Proc. U. S. Nat. Mus. 82, Art. 30: 1-14.

Holdenried, R., and Harvey B. Morlan. A field study of wild mammals and fleas of Santa Fe County, New Mexico (unpublished manuscript).

Keegan, H. L. 1949. *Euhaemogamasus utahensis* Ewing, 1933, redescribed as type species of new genus *Brevisterna* (Acarina; Laelaptidae). Trans. Amer. Micro. Soc. 68(3): 222-227.

Keegan, H. L. 1953. Collections of parasitic mites from Utah. The Great Basin Nat. 13(1-2): 35-42.

Morlan, Harvey B. 1955. Mammal fleas of Santa Fe County, New Mexico. Texas Reports on Biology and Medicine 13 (1): 93-125.

Zumpt, F. and R. M. Patterson. 1951. Further Notes on Laelaptid Mites Parasitic on Vertebrates, a Preliminary Study to the Ethiopian Fauna. Jour. Ent. Soc. S. Afr. 14: 63-93.

NOTICE TO CONTRIBUTORS

For uniformity and for economy of space, authors are requested to give generic and specific descriptions in telegraphic style, *i.e.* with minimal use of articles and verbs. Synonymies, bibliographies, paragraphing and punctuation will be edited to conform with the style used generally in this issue unless the author, when submitting his manuscript, specifically asks that no such changes be made.

CHARGE TO AUTHORS FOR REPRINTS

Number of Reprints	*Charge per page*	*Min'm. chg. 1-2 pages*
100	1.35	3.75
150	1.68	4.50
200	2.01	5.25
250	2.34	6.00
300	2.67	6.75
350	3.00	7.50
400	3.33	8.25
450	3.66	9.00
500	3.99	9.75

PRICE OF BACK VOLUMES

Back Volumes $2.50 per volume

Subscriptions for back volumes or numbers should be sent to Fred A. Lawson, Department of Entomology, Kansas State College, Manhattan, Kansas.

CONTENTS OF THIS NUMBER

The Walker Types of Bibionidae (Diptera)
D. Elmo Hardy 85

Morphology of the Thoracic Exoskeleton and Musculature of a Mayfly *Siphlonurus columbianus* McDunnough (Siphlonuridae, Ephemeroptera), A contribution to the subcoxal theory of the insect thorax.
Ryuichi Matsuda 92

Mites of the genus *Brevisterna* Keegan, 1949 (Acarina-Haemoganasidae)
R. W. Strandtmann and Dorald M. Allred 113